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SCIENTIFIC REPORTS

OF THE

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For the triennium ended 30th June, 1944

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REPORT OF THE DIRECTOR

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I. OUTSTANDING FEATURES OF THE TRIENNIUM

During the three-year period covered by the present report, India became an important base for the vigorous prosecution of the war in the Far Eastern Theatre. In addition to its normal work the Institute took up several investigations in furtherance of the war effort. These are described in the next Section. Locust control measures were also intensified in view of the imperative need to maintain and conserve maximum food resources of the country.

Another special features was the drawing up of plans for the co-ordination of agricultural research in India. This was taken up at the instance of the Imperial Council of Agricultural Research. During the triennium, plans drawn up by the Imeprial Mycologist for the co-ordination of Mycological research and by the Imperial Entomologist for the co-ordination of entomological research, were considered by special conferences of research workers called for the purpose and accepted.

The Institute suffered loss through the retirement on superannuation of Sir T. S. Venkataraman, who made outstanding contributions to the development of the sugar industry in this country, and of Rao Bahadur B. Viswa Nath, who was the Director of the Institute from 1936 to January, 1944.

II. RESEARCH AND INVESTIGATIONS

1. AGRONOMY AND CATTLE BREEDING

(a) *Agronomy*

Manurial experiments.—(i) A large scale experiment to determine the relative values of nitrogen in different organic manures and inorganic fertilizers and the estimation of their recovery by the crops and the changes brought about in the soil was initiated in 1941-42 on the recommendation of Sir John Russell. In view of the very low yields of the wheat crop due to double cropping during 1941-42 and 1942-43, no *kharif* crop was grown in 1943-44 and though the yields of wheat crop in this year were considerably improved, no statistical significance was observed among the various manurial treatment effects due to the extreme variability of the soil fertility. It has been decided to start a second series of experiment in a more uniform field from 1944-45 with an increased dose of nitrogen of 40 lb. per acre and with the inclusion of two green manure crops. The figures of crop yields obtained during the three year period are given in the report of the Imperial Agriculturist.

(*ii*) An experiment was started in 1940-41 to study differential effects of various manures on the production of berseem fodder and seed and the residual effect on the succeeding fodder crop of cowpeas. The experiment was repeated for two consecutive years on the same plots with manured berseem in the *rabi* and unmanured cowpeas in the *kharif* and has provided evidence of definite response of the berseem crop to phosphatic manuring in regard to fodder production as well as to the recovery of phosphoric acid and calcium in the fodder. The yield and the extent of recovery of PP_2O_5 and CaO increased with increased doses of superphosphate. In *kharif* 1943, cowpeas was grown in four blocks of the field and the remaining two blocks were kept fallow. Wheat was grown in the following *rabi* in all the blocks without any further manuring. The yields of wheat in the "fallow-wheat" rotation were higher than those obtained in the "cowpea-wheat" rotation, but the trends of variation due to residual effects were the same in both the rotation—the yields increased with the increased amount of phosphate added to the berseem crop whereas sulphate of ammonia which had depressed the yields of berseem also gave very low yields of wheat.

In a second experiment started in 1941-42, where lower doses of phosphates were used, the yields of berseem fodder increased with increasing doses of phosphates. This experiment has also been carried out for three consecutive years and it is proposed to grow unmanured wheat in the next *rabi*.

The residual effects of the manures applied to berseem in both the experiments did not produce in cowpeas responses of the same order as were shown in berseem.

The possibilities of improving the yield of the legumes by phosphatic manuring and at the same time of increasing the fertility of soils were also investigated. Peas both field and garden varieties, responded to phosphate manuring and the succeeding crop of unmanured maize gave higher yields in the plots following phosphate-manured peas than in the unmanured plots. Cowpeas, soybean and gram did not respond significantly to phosphate manuring.

(*iii*) Another series of experiments was conducted both at Delhi and Karnal to examine the effects of leguminous and non-leguminous green manure crops grown *in situ* and brought from outside, both with and without the application of fertilizers, on the yields of wheat. Of the legumes, cowpeas and sunnhemp have shown up better than the non-legumes such as sorghum and maize. Non-legumes gave better results when they were brought from outside than when grown *in situ*, but the reverse was the case with legumes. Addition of fertilizers, notably sulphate of ammonia gave increased yields of wheat.

Flood water farming experiments.—Experiments were undertaken at Delhi and Karnal to study the possibilities of increasing the crop area and ensuring crop production in those areas in Northern India where vast areas of cultivable land have to be left unsown due to insufficient rain and insufficient quantities of irrigation water, which is in great demand for *rabi* crops in October and the following months. If the surplus water in the rivers during the monsoon could be used to make up deficiencies in rainfall by flooding land during August or September, it might be possible to ensure regular *rabi* crop production in these precarious areas.

In the low rainfall year of 1941-42 when September flooding showed its value the wheat and barley crops at Delhi were destroyed by hailstorm just before harvest. In the other two years rainfall was adequate. The experiments will have to be repeated for a number of years before definite conclusions can be drawn.

Mixed farming experiments.—These long-term experiments have been laid out at Karnal and Delhi to ascertain how farming operations need to be adjusted, so that animals support the fertility of the land, and the land provides efficient maintenance for the animals, and operating together they provide for the farmer a surplus of food and crops and dairy produce for his cash requirements. At Karnal the experiment was conducted under (*i*) large-scale holding under mechanised farming of 400 acres, (*ii*) small-scale holding on 25 acres and (*iii*) small scale holding in eight acres. At Delhi it is being conducted on an eight-acre holding only. Two small holdings of 8-acres and 7·5 acres are also being run at Delhi to see the effect of 50 per cent. and 66·6 per cent. intensities of green manuring.

Artificial mulching experiments.—These experiments were continued both at Delhi and Karnal since 1941-42 with a view to increasing sugarcane yields by preventing the rapid evaporation of soil moisture by using crop residues such as sugarcane trash. Significant increases have been obtained in the yields of sugarcane and also in gram, wheat and barley in flood water farming experiments where artificial mulching has been used.

Fodder grasses.—With a view to testing indigenous grasses for fodder and pasturage, living specimens and seeds of grasses were collected from the different Provinces and States in 1942 and 1943 and grown in a nursery plot at Delhi. About eighty species so far have been indentified and they are being grown in larger plot for detailed study. Further additions to this collection are being made.

(*b*) *Cattle Breeding*

The Sahiwal herd at Delhi consisted of 229, 225 and 267 animals in 1942, 1943 and 1944 respectively and the Tharparker herd at Karnal of 245, 236 and 269 animals.

In the Sahiwal herd ' Chansuri ' gave a total yield of 12,312 lbs. of milk in her sixth lactation, ' Bilamba ' gave 11,290 lbs. and 11,320 lbs. of milk in her fifth and seventh lactations respectively. ' Birengee ' yielded 10,413 lbs. in her seventh lactation and ' Tamili ' gave 10,005 lbs. in her second lactation. Among heifers ' Tahskam ' and ' Shakbila ' gave 8,621 lb. and 7,171 lbs. of milk respectively. In the Tharparkar herd ' Phijji ' and ' Qairahmi ' gave over ten thousand pounds of milk in their third lactations. Among heifers ' Ramuni ' gave 8,263 lbs. and ' Qaisrami ', ' Qairahmi ', ' Mago ' and Ranbina ' gave over seven thousand pounds of milk in their first lactation. All these yields were recorded for a fixed lactation period of 306 days.

Statistical studies have been made of dairy data relating to the age of heifers at first calving, rate of growth of cows, weight of cows at service and at calving, etc.

Early maturity experiments.—These experiments were continued on the lines given in previous reports. In the Sahiwal herd in 1943-44 the heifers were mated at an average age of one year, six months and twenty-seven days at an average body weight of 640 lbs. The average yield of such heifers was 5,536 lbs. in 303 days.

In the Tharparkar herd in 1941-42 the average age at first service was one year, nine months and nine days with an average body weight of 643 lbs. The average milk yield was 5,363 lbs. in 298 days. The offspring of early maturity heifers and bulls were normal in all respects.

Calf Rearing.—At Delhi and Karnal all calves were reared on milk standardized to 3·5 per cent. fat with skim-milk on a weekly scale based on one-tenth birth weight for a period of two months. The mortality among pail-fed calves at Delhi ranged from 7·8 to 11·5 per cent. and that of Karnal from 11 to 24·5 per cent. The chief causes of death at Delhi and Karnal were calf pneumonia, naval ill and dysentery.

2. Crop Improvement

(a) *Crops other than sugarcane*

Wheat Studies.—The study of 1,056 samples of wheat collected in 1940-41 from all parts of India was continued and detailed observations were made on morphological and other characters. A set of 220 varieties was grown in 1942-43 and 1943-44 simultaneously at New Delhi, Pusa and Coimbatore to study their behaviour when cultivated under such sharply contrasting conditions of soil and climate. At Simla the study of the collection of hill wheats was continued. Work on the registration of wheat varieties was also taken up and all the samples received for registration were described in respect of nearly twenty-five characters, following standard schedule laid down for the purpose.

Wild plants being frequently more resistant to diseases and to adverse conditions than their cultivated relatives, a study to obtain knowledge regarding the less well known cultivated wheat species, wild wheat species and of species of other genera allied to *Triticum*, and to exploit the possibilities of utilizing these for the amelioration of the wheat crop was commenced. In this connection, a collection of almost all the wheat species and of such grasses as *Agropyron*, *Aegilops*, *Lolium*, *Lepturus*, etc., was receiving attention. Crosses between these and the cultivated wheat species were made and a number of intergeneric hybrids were subjected to cytogenetical study.

Experiments on smut resistance were carried out as a co-operative investigation by the Sections of Botany and Mycology, and a large number of wheats were tested.

Progress was made in breeding rust-resistant wheats for the hills in collaboration with Dr. K. C. Mehta with a view to synthesizing varieties resistant to the yellow, brown and black rusts and with good agronomicc haracters. Tests of varieties and hybrids for both seedling and adult resistance were carried out at Simla and for adult resistance only at New Delhi. A large number of crosses between the best cultures resistant to the brown and yellow rust respectively were under study. In order to evolve varieties which would unite resistance to all the three rusts, a double cross has been made on a large scale, utilizing the best of the brown and yellow rust resistant hybirds, and also a vulgare variety from Kenya which is highly resistant to black rust.

Potato Breeding—Investigations in potato have been oriented mainly towards the production of disease-resistant and high-yielding hybrids suitable for the plains and the hills in India. As a preliminary step, therefore, the study of all the Indian varieties of *Solanum tuberosum* inaugurated before with a view to eliciting the range

of characters available for breeding was completed and the results written up in the form of a bulletin which is in the press. A similar study of all the commercial varieties of *S. tuberosum* from abroad and of species of tuberiferous *Solanums* from South and Central America was continued for evaluating their salient traits of economic value which could be utilized towards the improvement of the Indian potato. Progenies from crosses between *S. tuberosum* and *S. Andigenum*, *S. demissum* and *S. curtilobum* and a number of intervarietal hybrids between suitable Indian and promising foreign varieties of *S. tuberosum* were grown and studied with a view to building up lines resistant to the late blight, viruses and frost. Beginning with the summer of 1941, trials of new hybirds evolved at Simla were conducted at a number of hill stations in the Provinces and the States. At all the places some of the Simla hybrids gave encouraging results. In Assam, one of the Simla hybrids tried at Shillong, is under multiplication for general distribution. An intermediate Hill Station at Bhowali was established during the year 1943-44 for multiplication of promising hybrids which would be sent for co-operative trials in the plains.

Disease resistance studies.—The work of testing and selecting wilt resistant strains of pigion-peas from among the progenies of the cross I. P. 24 × I. P. 51 was continued at Delhi and Pusa. A few cultures have shown a high degree of resistance to the wilt.

The selection of linseed strains resistant to rust (*Melampsora-lini*) from crosses between I. P. strains and resistant exotic types was continued at Delhi and Karnal. The strains were also tested under conditions of artificial infection at Dr. Mehta's Rust Research Laboratory.

Cytogenetical Studies.—The large number of types of the cultivated *Brassicae* collected from all over India were under study from morphological, genetical and cytological stand-points and a final classification of these into species and varieties has been drawn up. The variability of characters within and between species has been worked out and a key for indentification made. The origin of one of the cultivated species, *B. juncea* (2n=36) has been experimentally demonstrated. The species has actually been synthesized by crossing *B. campestris* (2n=20) and *B. nigra* (2n=16) and later doubling the chromosome of the sterile hybrid with colchicine. The study of inheritance of self-sterility in Toria (*B. campestris*) was continued and the presence of two series of allelic factors governing the inheritance of this character was tentatively established.

Tetraploidy has been successfully induced in the several cultivated species of mustards, namely *B. nigra* (2n=16), *B. campestris* (2n=20), B. *juncea* (2n=36) and *Eruca sativa* (2n=22) and large populations of tetraploids were grown and studied for their growth, fertility and other economic characters compared to their corresponding diploids.

Progenies of tetraploids in gram and chilli were grown and further studied with regard to morphological and physiological characters and selections for improving their fertility were made. The chillies were grown at Pusa, Simla and Guntur also. While the tetraploids have retained their gigas nature they have not substantially improved in fertility in spite of repeated selection for fertility. The tetraploid grams were found to be as susceptible to wilt as the diploids and owing to heavy incidence of the disease in the previous years it has not been possible to multiply the seeds of these tetraploids for trial in other centres.

Tetraploids were induced by colchicine in *Sesamum orientale* and in a sterile interspecific cross, *S. orientale* (2n=26) × *S. prostratum* (2n=32). Tetraploid branches *S. orientale* obtained by treatment of vegetative buds had bigger pollen. Unlike chilli and gram tetraploids the sesumum tetraploids possessed a very high percentage of good pollen. The seeds of the tetraploids were bigger than those of the diploids. The completely sterile hybrid between *S. orientale* and *S. prostratum* turned fertile on treatment with colchicine and produced many capsules with a good number of seeds. These seeds were bigger than those of either parents. The seed gave rise to true breeding vigorous hybrids combining the character of the two parents. The umphidiploids in spite of regular meiosis produced varying amounts of sterile pollen and showed variable setting.

Physiological studies.—Drought resistance studies with wheat were in progress with four Indian varieties and three exotic varieties. In a complex experiment, the effect of drought at three different growth phases on pre-treatment and control seed of the seven wheat varieties was studied. One half of the number of experimental boxes received water while the other half received sodium chloride solution. Consistent results were obtained during the three years which pre-showed that (*i*) pre-sowing hardening treatment of seed induced resistance to drought, (*ii*) resistance to drought could be evaluated by growth analysis and yield data, (*iii*) there appeared to be some correlation between phasic development and drought resistance, (*iv*) correlation between drought—and alkali-resistance was established (*v*) plants obtained from pre-treated seed flowered earlier by a few days, (*vi*) 260 Indian and exotic wheat varieties could be classified into different flowering groups which were characterised by definite growth standards.

The photo and thermo requirements of the same seven varieties used for the drought and alkali-resistance experiments were also determined. The results show that (*i*) there is a close correlation between growth and the photo and thermal response of wheat, (*ii*) after the completion of the thermo-phrase, the developmental process appears to be essentially photocatalysed, (*iii*) there appears to be a close interdependence between growth and development.

(*b*) *Sugarcane*

Sugarcane breeding.—About forty crosses were effected with the object of evolving early ripening and high sucrose seedlings. Besides the above, over two hundred other crosses were effected. These were of an experimental nature to observe the type of seedlings obtained and to assess the value of new combination.

The following Sorghum crosses have yielded quite promising seedlings : (1) Co. 349 × (Vellai × Sorghum Durra, Stapf), (2) P. O. J. 2878 × (Vellai × Sorghum Durra, Stapf). The utilisation of the parent S. C. 851 has been kept in abeyance till more is known about the performance of the seedlings already obtained from it.

Three bamboo cross seedlings, *viz.* Co. 562, Co. 563 and Co.564 have already, been distributed for trial at the Provincial Stations (in February 1942) and a fourth *viz.* Co.606 was similarly distributed in February 1943. The performance of these will be watched with a view to adjusting the Bamboo hybridization on the basis of the reports on these seedlings. The utilization of the bamboo itself (direct cross) is attended with certain difficulties, which in themselves are by no means insurmountable. These are, the irregular and indefinite nature of Bamboo flowering, secondly the difficulty of synchronising bamboo flowering with that of sugarcane and

thirdly the rather rare germination of bamboo pollen on the stigmas of sugarcane. Because of the above but chiefly because of the fact that the direct bamboo blood introduces impurities in the juice it is proposed to utilise in the future crossing work such of the desirable Sugarcane × Bamboo seedlings that are already available and if they prove unsatisfactory, the direct crossing of bamboo will again be resorted to to secure, if possible better F_1 seedlings. During the 1942-43, and 1943-44 crossing seasons the bamboo hybrids B.h.V., B.h.IX and B.h.IX-57 were further utilised in about ten crosses with certain high sucrose canes.

Cyto-genetical Studies.—Chromosome numbers of ten more forms of *Saccharum spontaneum* were determined and a scrutiny of the numbers with reference to the places of collection reveals that forms with low numbers (*i.e.*) n-27, are found in North or North West part of India. A steady increase in chromosome numbers occurs in forms collected in tracts in a South Easterly direction. The Lahore and Dehra Dun types have n-27 while the Bihar forms have n-28, 30, 30-1, 32 and 36. The Assam and Burma forms have n-40 whereas East Indies types have n-54 and 56.

Physiological Studies.—Photoperiodism experiments for inducing flowering in non-flowering varieties and for hastening or delaying the reproductive phase in certain sugarcanes, used as parents, have yielded interesting results. Some varieties a *Saccharum spontaneum* Burma, which do not flower at Coimbatore, have been induced to flower by considerably reducing the daily photo period about eight weeks prior to commencement of the flowering season. Similarly some other varieties like Co.421, P. O. J. 2725 and *Saccharum spontaneum* (Tabongo) which flower very early in the season have been made to flower late by a period of about two months, by altering the day length at suitable stages in the life of the plant.

Soil, Fertilizer and Plant Nutrition Investigations-Soil Studies.—Two soil maps of India, one in colour and the other in black and white, were published to show the major soil divisions and their distribution in India based on colour classification. Further charts and maps showing the distribution of nitrogen and phosphorous in various types of soils were also prepared. Besides this number of charts and maps were prepared to bring out the relationship of the types of soils and their distribution with climatic and other physical factors. Charts and maps were also prepared for showing the distribution of important chemical constituents and their ratios in different types of soils.

The present methods of expressing the different soil characteristics being far from satisfactory as they do not often lend themselves to easy adoption in practice, a new system of presenting the data of aggregate or mechanical analysis was devised.

In another study, 42 surface soils from different parts of India representing various soil types were studied for phosphate fixation purpose. In general the soils of the Indo-Gangetic plain from Assam to the Punjab had low fixing power. The soils of the geneissic area including coastal alluvium as also from southern India including coastal parts had medium fixing power and the black cotton soils of Central India including Central Provinces had high fixing power for phosphate. The effects of pH, clay content, total exchange capacity, exchangeable bases SIO_2/R_2O_3 ratio and other soils characteristics on the phosphate fixing capacity were worked out.

The phosphate fixation was inversely related to SIO_2/R_2O_3 ratio and directly related to pH, clay contents, total exchangeable capacity and exchangeable bases. The black soils had the highest fixing power while brown soils were of low fixing capacity. The red, pink and grey soils were intermediate in this respect.

A soil survey of the whole of the cultivated and reserved areas of the Delhi farm was carried out.

Study of the relative value of nitrogen in manures and fertilizers.—This problem was suggested by Sir John Russell for investigation at the Institute. 1,080 soil samples were collected from the area which was selected for the experiments and the detailed study of variations in N, P and K content in these plots was made.

In this connection rapid methods of estimating N, P and K were developed to permit the handling of large numbers of samples as well as to give data for allowing small differences to be significant. A study of the sampling technique and the errors in sampling together with personal earrors in various estimations was also under taken.

Microbiological Studies.—The decomposition of F. Y. M. under anaerobic condition was studied. Laboratory experiments indicated the possibility of its use on a large scale. But it was first considered necessary to understand any difficulty that might be encountered while experimenting on a semi-large scale using F. Y. M. from two or three cattle.

The nitrogen content of the fermented material was 1·71 per cent. The nitrification experiments showed that the product was superior to F.Y.M. or composed and nitrified easily. The experiments to compare the value of differentlyprepared F. Y. M. showed that anaerobically fermented manure was superior to all other types prepared in open pit, covered or when freshly sun-dried.

The relation between microbiological status and the soil fertility was studied with a view to elucidate the relation of microbiological activity to soil fertility and plant growth. Soil samples were collected periodically from the plots of the permanent manurial series (old), at Pusa, where definite fertility levels were established. Numbers and activities of the soil microflora taking part in ammonification, nitrification, cellulose decomposition, nitrogen fixation, denitrification, and carbon dioxide evolution were determined in each set of soil samples. It was observed that the bacterial population and ammonifying nitrifying and carbon dioxide evolving powers, were higher the soil samples from plots receiving green manure plus super, farmyard manure, or complete artificial fertilizers (N+P+K) which were of high fertility than the orr esponding values in the soil samples from the green manure treated plot, potassium sulphate treated plot and the unmanured plot which were of low fertility.

A fair degree of correlation was obtained between the soil microbiological activity as determined by the evolution of carbon dioxide from the soil and crop yields from plots at Delhi, receiving nitrogen in different forms, and those from plots of the permanent manurial series at Pusa.

Irrespective of the time of taking the sample, definite levels of microbial activity were established in the deffierent plots at pusa and the order of activity was also the order of crop yields. The addition of deficient element for elements

in the form of fertilizer for proper microbial activity increased the microbiological activity which enhanced the formation of available plant nutrients in the soil resulting in the increase of crop yields. From this the possibility of finding the manurial needs of a soil by its response in carbon dioxide production was envisaged.

Biochemical Studies.—Experiments were set up to judge the nutritive quality of wheat grown under the following treatments in the first instance in Pusa soils : (1) Green Manuring, (2) F.Y.M., (3) Complete artificials. The growth curves of the set of albino rats showed that the best growth was obtained with green manured wheat closely followed by F.Y.M. wheat. Wheat raised with organic manure was very definitely superior to the wheat raised with complete artificials. One interesting point brought out was that up to 41 days the growth curves under all feeding treatments did not show appreciable differences, but the differences became augmented slowly as the period of experimental feeding increased and after 72 days the differences in growth in different sets were very pronounced. This indicated that erroneous conclusions could easily be obtained if the experiments were not continued over a long period.

The rats fed with grains raised on organic manures gave litters while those fed on grains raised on artificials failed to produce. It was, therefore, not possible to study the effect of these diets on successive generations.

INVESTIGATIONS ON PESTS OF PLANTS

Insect vectors of virus diseases.—Experiments carried out earlier at Pusa had shown that fish oil rosin soap, sprayed four times at weekly intervals in the nursery and in the field on plants from the time they were about 6-8 weeks old satisfactorily controlled the white-fly, (*Bemisia tabaci*), transmitter of the leaf-curl disease. Field trials on a large scale were made with various insecticides during the two seasons of 1941-43, and these confirmed the results obtained previously. As a result of sprays, the disease was reduced to the extent of about 40%.

Insect population studies.—Observations on the oscillation in the population of spotted bollworm were started at Karnal in the autumn of 1941, under a special scheme of research. Attention was directed chiefly to develop a standard method of evaluating the population of insects and of analysing the various factors affecting the population. An examination of various satistical methods of field census have shown that data on incidence of bollworms, collected in the ordinary way, are not sufficiently reliable for an ecological investigation, unless the population per unit area or volume is considered. Thus the highest percentage incidence of spotted bollworms during three seasons, 1941-42, 1942-43, 1943-44 was 10% 5% and 21% respectively, whereas the highest population per acre for three seasons work out to be 23,000, 20,000 and 22,000. Thus percentage incidence data would have indicated undue apprehension in 1943-44 and given a false sense of security in 1942-43. Two new instruments, Biograph and Biometer, were devised to give correct idea of the duration of life-cycle under any range of temperature.

Pests of stored food-stuffs.—Studies on the incidence and biology of important insect pests of jowar were started as a part of the scheme of the Imperial Council of Agricultural Research from April 1942. As a result of surveys conducted in various parts of India, it has been found that about a dozen insects do appreciable damage to

stored jowar and of these the important ones are *Sitophilus* (*Calandra*) *oryzae*, *Rhizopertha dominica*, *Sitotroga cerealella*, *Corcyra cephelonica*, *Tribolium castaneum*, and *Silvanus surinamensis*. It has been determined that moisture content of the grain has a great influence on the incidence and development of the pests that when the moisture content is low, 7% or less, these pests become sluggish and die soon, but at a moisture content of 12% or more they breed well. Heat sterilization experiments showed that 15 minutes heating at 55 C. killed all pests but the seeds were not affected. A large number of inert dusts and chemicals have been tried as preservatives and of these calcium carbonate (1:200) has given the best result and an inert dust of rock phosphates (indeginous) is very promising.

A comprehences survey of the indigenous methods of storage in vogue in various parts of India carried out in co-operation with regional Entomologists was completed.

Biological control of pests of sugarcane.—The central part of the Scheme for research on insect pests of sugarcane, which started in August 1936, was wound up in March 1942. Instead a revised Scheme, which had for its object critical trials or some already known methods of control, was started with centres selected in (*i*) Punjab, (*ii*) U.P., (*iii*) Bihar, (*iv*) Hyderabad (Deccan) and (*v*) Madras. The Biological Control part of the original scheme was however further extended and seven centres were selected for *Trichogramma* colonization experiments.

At New Delhi, in addition to mass-breeding of *Trichogramma*. ecological studies on this and some other parasites were taken up. It was found that the most suitable temperatures for rearing *Trichogramma* and its laboratory host Corcyra were 74°F to 78°F and relative humidities of 50% to 60%. 150 million *Trichogramma* were produced in the laboratory during 1942-44. Supplies of this parasite were made to Lyallpur, Bombay, Meerut, Ranchi, Pusa, Bhopal, Cuttack and Setabganj to serve as nucli for mass cultures and where it was liberated in sugarcane fields to reduce the attack of borers. The results obtained so far show that in some areas like Cuttack the parasite introductions are useful in reducing the pest.

Insect pests of potatoes.—Insects attacking potato in the field and in storage received special attention. The life-history of three important sucking insects, namely *Empoasca kerri* var. *motti*, *Megacoclum stramieum* and *Myzus persicae*, were studied in detail and their host plants recorded. *E. kerri* was quite common throughout the season ; nymphs and adults feed usually on the under side of the leaves. During winter months the life-cycle was completed in one months time. *M. stramieum* was common from October to December, it completed the life-cycle in four weeks' time. *Myzus persicae* was recorded from 31 host plants belonging to 14 different Natural Orders. No oviporous females were found, nor have they been recorded so far from any part of India.

Studies of termites.—The study of methods of control of termites damaging sugarcane Setts was initiated in 1941. The experiments were carried out at Karnal with setts treated with paris-green, lead arsenate, arsenic, coal-tar and coal-tar-soap-emulsion. A month after treatment the muximum attack of termites was confined to the control setts and those soaked in water prior to sowing. Treatments which gave promising results were in the order of their efficiency (1) Corrosive sublimate solution (2) Coal-tar (diluted) and (3) Paris-green suspended in cocoanut oil.

A large collection of termite, adults, soldiers and workers from the environs of Delhi, was made to determine the common species found. While making these collections, it was observed that the grubs of two beetles, *Conocephalum depressum* and *Rhitonata impolita* were predators on the workers of terminces about 3 inches below the surface of the soil.

Studies of house-flies.—Systematic and regular collections of the house-flies occuring at Delhi were made. From the collections made, it was seen that the largest number of house flies appears in August, September when it is hot and humid, and the lowest number in January or May when it is too cold or too hot and dry. Throughout the year *Musca nebulo* and *M. vicina* are the most abundant species. *M. vetustissima* and *M. verburyi* occur in small numbers throughout the year, while *M. pulla* and *M. ventroza* occurred in very small numbers from August to October.

A method for the disposal of dung and litter which does not permit of house fly breeding was developed.

Survey of Icerya purchasi.—A scheme for the survey of the well known scale insect *Icerya purchasi* in the peninsular India was started on 1st July 1943. As a result of the surveys undertaken this pest has been found for the first time (*a*) at Bangalore, Mysore, Krishnarajasagar and on Nanda hills in Mysore State, (*b*) at Tellar, Munnar, Devikolam in Travancore State (*c*) in parts of Nilgiri and Salem districts of Madras Presidency and (*d*) at Poona in Bombay Presidency.

There was considerable increase in the number of crop pests received from Provincial Entomologists for identification and of enquiries regarding the occurrence of pests and parasites in various parts of India and neighbouring countries.

5. Locust Control.

The direction of the locust campaign in India and in parts of Arabia and Persia continued to engage the Imperial Entomologist. As the Locust pest is not only of all-India but of International importance, it is essential that all provinces and States should take adequate control measures on a coordinated plan. To achieve this object, representatives of various Provinces and States met in a conference convened by the Government of India at Delhi in April 1942 and approved of a Scheme under which every administration undertook to destroy the pest in its territory but the expenditure incurred in all desert outbreak areas, that were scheduled was to be allocated to all the beneficiary provinces, and States irrespective of the fact whether breeding took place in them or not. This scheme was to be administered by the Government of India and put in charge of the Imperial Entomologist. As locust situation in Iran and Arabia is of great concern to India, four Locust Delegations were sent to these countries during the period under report. The Imperial Entomologist attended the International Locust Conference held at Teharan in October 1942 and at Cairo in June-July 1943 and the Superintendent, Locust Substation Karachi served as a member of the Teharan International Locust conference on several occasions.

Details of the anti-locust operations will be found in the report of the Imperial Entomologist but it may be stated here that the control work was so thorough in India that unlike in the past no swarm was allowed to develop and go to Persia and the Indian crops practically suffered no damage at the hands of this notorious pest.

6. Plant Diseases.

Diseases of cereals.—Investigations on loose smut of wheat started in 1936-37, made considerable progress during the years under report. Some of the varieties tested in the above investigations have considerably remained free from infection for several years and there is no doubt that they possess immunity to loose smut.

The question of physiological specialisation in loose smut was studied but the use of the Canadian differentials for identifying the physiological races of loose smut did not give satisfactory results and certain Indian wheats were therefore selected to serve that purpose. Results obtained in 1943-44 showed that there may be two physiologic races in India but this has to be confirmed by further work.

Reaction of wheat varieties to flag smut which is externally seed-borne, was also tested. In 1942-43 when abundant inoculum became available, 129 varieties were tested of which 53 took no infection, 19 only slight infection, while the rest showed high infection. Similar results were obtained in 1943-44 also.

Several experiments were laid out in 1941-42 and 1942-43 to determine the mode of transmission of the 'Karnal bunt' without a knowledge of which it is not possible to devise methods for its control. In the latter year more or less convincing evidence was obtained that the disease is not systematic but local and air-borne. In 1943-44 several hundred of ears were infected both at Delhi and at Simla at the flowering time and it has now been definitely shown that the disease is air-borne.

In order to devise measures to control the covered smut of barley, experiments were laid out at Karnal and at Delhi. Two years' trials have shown that sulphur dust of extreme fineness or dust made from Baluchistan sulphur ore, is able to considerably check the disease.

As a treatment against the grain smut of jowar, crude Baluchistan sulphur of 60 or 75 per cent purity, ground to pass through a sieve of 100 mesh per linear inch, was compared with pure sulphur, formalin dust (6 per cent of formalin on charcoal dust) and Agrosan G at a dosage of 1 : 250 by weight. The results showed that Baluchistan sulphur is at least as good as pure sulphur and only very slightly if at all inferior to Agrosan G.

Reputed failures of well known see-dressings to control the leaf stripe disease of rice disease, whereas they control the leaf-stripe diseases of other cereals, led to a thorough examination of specimens of infected leaves and seeds to determine whether the disease is really due to *Helminthosporium oryzae*. It was found that just over a quarter of the specimens obtained from all over India showed the presence of *Helminthosporium* whereas over one half showed the presence of *Curvularia*.

Diseases of pulses.—Experiments to determine the resistance of pigeon pea varieties to *Fusarium* wilt were continued. In 1942-43, 20 varieties bred by the Imperial Economic Botanist were tested. Ninteen of these varieties were infected from 79 to 100 per cent. but the remaining one variety, A. 126-4-1 failed to take infection. These were again tested in 1943-44 of which IP 80, IP 41, C. 38, C. 15 A. 126-4-1, D. 16-17-2 Pt. 12 and D. 33-4-22 were proved to be resistant. Six varieties from Coimbatore were also included in the experiments but all of them, including Bulsar White (reputed to be resistant) fared badly.

Experiments on the effect of date of sowing on the incidence of gram wilt were conducted for the fourth and fifth successive seasons. The September sown crop was practically destroyed by wilt but in October sowings wilt was very appreciably reduced.

Isolations were continuously made during the season from 'wilted' plants and in several cases *Operculella padwickii* has been invariably isolated. In 1941-42, 32 varieties were tested for resistance to foot-rot in pots and the test repeated the next year. No clear case of resistance to the disease was however noticeable. Date of sowing tests indicated that even with this disease, early sowing is detrimental to the crop.

Potato diseases.—In 1941-42, the late Blight fungus was brought into culture, growth being particularly good on carrot extract agar. But the cultures were lost due to a breakdown in the refrigerator. The fungus was then treated as though it were an obligate parasite and was maintained on its host throughout the year. In 1942-43, therefore, 241 varieties and hybrids could be tested for their resistance. Thirty-seven varieties did not take infection, being either immune or highly resistant, and the remainder proved to be highly susceptible. In 1943-44 243 varieties and hybrids were tested, of which 61 varieties proved to be highly resistant.

Fusarium solani was found to be causing severe rotting of potatoes both in the field and in storage at Simla and a highly sporing isolate was obtained. In 1941-42, fifty varieties were submitted to the resistance tests by spraying the tubers with a suspension of the spores and placing them in a moist chamber. They varied from complete susceptibility to a very high degree of resistance. In 1942-43 the optimal temperature for infection was determined and found to be 25°C. Infection took place rapidly also at 20°C and 30°C but at 35°C and above bacterial rotting set in and at 15°C. and below, infection was exceedingly low. In 1943-44 tubers of 60 varieties and hybrids were tested. Seven varieties showed no infection and five less than ten per cent. The remainder showed infection ranging up to 100 per cent.

Virus diseases and seed certification.—It has been amply established that virus diseases cause a great reduction in yield and the subsequent deterioration of the potato crop. Extensive studies have therefore been undertaken with a view to securing a nucleus of disease free material which could be utilized in a seed certification programme. Observations on the incidence of virus disease at Delhi were in progress. It was noted in 1941-42 that in the spring crop, virus infection was at its highest from the first week of February to the middle of March and lowest after the third week of March indicating masking of symptoms. In 1942-43 it was found that in the winter crop there was practically no masking. Differentials for the detection of virus were multiplied regularly and with their help Solenum viruses 1, 2 and 3 were isolated from several varieties, while indication of at least two other viruses was obtained. Observation on loss of yield in *Phulwa* variety due to the various kinds of mosaic indicated that the negligible type of mosaic resulted in 25·5 per cent loss in yield while the severe type reduced the yield by 92·3 per cent.

In 1941-42 an extensive survey was undertaken for finding out localities, if any, where the crop can be grown with a minimum of natural spread of virus diseases. Observation on the incidence of aphids, vectors of virus, were also recorded at different altitudes. Kufri (8000 ft. above sea level) near Simla hills, was finally selected as the site for the central station for seed Potato Certification.

Sugarcane diseases.—In 1941-42 a particularly virulent strain of the Red-rot fungus was isolated and 79 varieties were inoculated with it. Thirtysix proved to be moderately resistant, 30 moderately susceptible and 13 were highly susceptible. In the resistant varieties, the reddenning caused by the fungus was not more than 15 inches but in the susceptible ones, it spread to over 30 inches, maximum being 60 inches. In 1942-43, 98 varieties were tested and a moderate degree of resistance was shown by 22 varieties. In 1943-44, 116 varieties were tested and 22 varieties proved to be moderately resistant.

Experiment to determine the modes and sources of infection clearly established that infected debris in the soil and irrigation water in which the spores are present, can bring about infection. Young, and old, uninjured nodes also afforded entry to the fungus thus disproving the view held previously that to successfully control Red-rot it was enough to use clean setts.

The occurrence of a light coloured, highly sporing and virulent strain of *Colletotrichum falcatum* in the areas where Red-rot occurred in epidemic proportion led to the suspicion that there may be parasitic races of this fungus and experiments were started to find if such was the case in 1941-42. A large number of isolations that were made showed that there are principally two races, a light race referred to above and a race with dark coloured mycelium. While the former was highly pathogenic, the pathogenicity of the latter was less so. Among the light coloured races, there were however, some isolated which were weakly pathogenic and in the dark coloured race some isolated were encountered which appeared to be more virulent.

Varietal resistance to the wilt and smut diseases was also studied.

7. Special investigations in furtherance of the war effort.

Besides anti-locust work which has been described on a previous page the following deserve mention :—

Curing of hides .—A good deal of edible salt is used in the curing of hides. In order to conserve as much edible salt as possible, the possibility of using impure bittern salts from Sambar lake was examined. Naturally formed bitterns salts from partially exhausted mother liquor are contaminated with aerobic bacteria and, if used in the curing process cover the hides with a red, foul-smelling slime causing a red discolouration of the hides, known as " red-heat ". Manufacturing bitterns salt by depositing it out in the same clean pans that are used for crystallising out the edible salt, resulted in a better product but if denatured with Chlorazol blue and kerosene, proved to be the best from the curing point of view, giving a clean hide. Taking into consideration, however, that rapid and often heavy infestation of even mined salt takes place when exposed to commercial storage and transport conditions, it was decided that manufactured bitterns salt, despite the presence of chromogenic halophilic bacteria, is serviceable for curing and pickling hides and thus conserve edible salt for human consumption.

Substitute rubber plants.—The situation arising out of the war necessitated investigations on the possibility of developing new sources of rubber in the place of the commercially important *Hevea* rubber. As a first step a team of botanists was sent to survey the country to note the occurrence, distribution and abundance of agricultural types of laticiferous plants likely to be source of rubber.

As a result of this survey and the analytical work carried out by the Section of the Imperial Agricultural Chemist, *Cryptostagia grandiflora* was re-discovered as the most likely plant for exploitation in this emergency. As very little was known about the methods of propagation, growth and productive capacity in terms of yield of latex rubber of this plant, collaborate investigations with the Chemical Section and the Rubber Section of the Supply Department were undertaken. The following results have been obtained : (*i*) propagation by seed is to be preferred to cuttings, (*ii*) presoaking of seed in water for 24 hours helps in securing larger, quicker and more uniform germination, (*iii*) raising of nurseries and transplantation of seedlings is ordinarily to be preferred to broadcasting the seed, although the latter method, which is very much less expensive, can be adopted in places of good rainfall and moderate temperatures (*iv*) seed-rates for nursery and field planting have been worked out and methods of raising nurseries and transplanting have been recommended, (*v*) The plants raised from seed grew slowly in the early seedling stage, but later the growth was fast and luxuriant. The growth was active during the rainy months of July September and again during March-May. During November-February there was marked setback in growth and defoliation was observed. (*vi*) Pruning experiments were undertaken to determine the best season and the best type of pruning in orders to accelerate growth particularly with regard to ' whip ' branches for utilisation in tapping of latex and for growing plants for mechanical extraction of rubber.

82 samples of latex from different latex bearing plants were analysed. Ultimately the plant *Cryptostegia grandiflora* was found to be the most promising. A method of tapping the plant by attaching multiple receptacles to the cut ends was evolved which gave appreciable collection of latex having considerable amount of rubber hydrocarbon. Tapping of the plants once in three days gave maximum economic yield of rubber. The method of coagulating the latex by dilution with water in the ratio 1 : 5 was found to be satisfactory.

Production of Butyl alcohol and acetone by microbiological fermentation.—A strain of organism was isolated from maize roots, capable of fermenting maize mash to butyl alcohol and acetone. This organism also fermented molasses if sufficient proteins in the form of oilcakes were added to give proper carbohydrate protein ratio in the mash. The production of butanol and acetone was found to be 25 % and 12·5 % of the carbohydrate respectively. Besides this organism, several other organisms were isolated from other sources for examining their power of producing butanol. The efficiency of the organism to produce butanol was highly variable and depended on the history of their cultivation on different media. The efficiency was found to be directly related to the sporulating tendency of these cultures. Experiments were carried out to restore the efficiency of cultures which had deteriorated and it was observed that repeated transfers of heated spores at short intervals in maize broth were helpful. Various cereals as well as carbohydrates were used as sources of energy for the organisms and the fermentation was equally good in all the cases.

Material for water and fire proof paints.—Alternative sources of protein in place of casein were examined for the Camouflage Department as to their suitability use in preparation of water and fire proof paints. Proteins isolated from various oilcakes were found to be suitable and a practical way for their extraction was worked out.

Utilization of ammonium nitrate and its mixtures with T.N.T. from ammunition stores as a fertilizer and the problem of their storage.—A consignment of ammonium nitrate and its mixtures with 1%, 2% and 3% T.N.T. was sent by the Master General of Ordnance. Various materials were mixed with ammonium nitrate to prevent the formation of hard cake. With some materials like soap-stone, calcite, yellow ochre china clay and fuller's earth the formation of hard lumps was retarded and some materials like Delhi soil apatit and boneme al augmented the formation of hard lump Experiments to find out the manurial value of the fertilizer in Delhi and Karnal so were laid out.

Air foam compounds as fire extinguisher.—In the course of studying the problem on the isolation of the alkaloidal principle from Solanum *xanthocarpum* it was observed that the colloidal solution of the base gave copious and stable foam. This suggested its use for preparing a compound as a fire extinguisher. The acid extract when neutralized gave standard amount of foam in 5 % solution. By using unripe fruits and alcohol for extraction of the base it was possible to obtain a concentrated solution. When 5% soapnut powder was added to stabilise the base the compound gave standard amount of foam in 1% solution.

III. GENERAL ADMINISTRATION

Charge.—Rao Bahadur Dr. B. Viswanath continued as Director and Imperial Agricultural Chemist till he proceeded on leave preparatory to retirement with effect from 1st February 1944 when Dr. H. S. Pruthi Imperial Entomologist took over as Officiating Director in addition to his own duties as Imperial Entomologist.

Staff.—Rao Bahadur (since Sir) T. S. Venkataraman, Sugarcane Expert, Coimbatore, retired from service with effect from 30th June 1942 on the expiry of the three years' extension of service granted to him and Mr. N. L. Dutt, Second cane Breeding Officer was appointed as Sugarcane Expert.

The Botanical, the Entomological, the Agricultural and the Mycological Sections remained in charge of Dr. B. P. Pal, Dr. H. S. Pruthi, Mr. C. H. Parr and Dr. G. Watts Padwick respectively during the triennium under report. In 1943 Dr. G. Watts Padwick was sent on deputation to China where he acquainted the Chinese Mycologists and Plant Pathologists with the work that is being done in India in their respective subjects.

Schemes of Research financed by the Imperial Council of Agricultural Research. The Schemes of Research financed by the Imperial Council of Agricultural Research which functioned at this Institute during the triennium are mentioned under section IV below. The Botanical Section, Pusa, which was being financed by the Imperial Council of Agricultural Research up to 1940-41 was taken over by the Government of India as Part of the Institute with effect from 1941-42.

The following Research Schemes were sanctioned by the Imperial Council of Agricultural Research during the triennium :—

Scheme for Research on Sugarcane Physiology (1942-43).

Schemes for Research on Jowar Storage (1942-43).

Scheme of All India Soil Survey (1942-43).

Scheme for carrying out survey of Potato growing areas (Potato certification scheme) (1942-43).

Scheme for Survey of *Icerya purchasi* (1943-44).

Type-culture Fungi Scheme (1943-44).

Intermediate Hill Station for Potato Breeding at Bhowali (1943-44).

Training.—The number of students admitted for postgraduate training and other training and those who completed their courses satisfactorily may be seen in Appendix I.

Library.—The total number of publications received in the Library both in exchange and by purchase and the number of books which were issued out on loan are shown below :

Year.	Accession.	Loan.
1941-42	1,993	4,585
1942-43	1,085	4,044
1943-44	2,308	4,703
Triennial Total	5,386	13,334

IV. ACCOUNTS

The total expenditure of the Institute and its Substations at Karnal and Coimbatore during the triennium amounted to Rs. 8,86,084 ; Rs. 9,09,721 and Rs. 11,16,706 respectively as shown below :—

	1941-42.	1942-43.	1943-44.
Superintendence (Director, Estate and Engineering Establishment).	2,22,664	2,08,948	2,33,702
Expert Staff Headquarters—			
Statistician	4,951	5,291	8,951
Imperial Agricultural Chemist	62,139	64,754	68,889
Imperial Mycologist	46,280	37,272	42,634
Imperial Entomologist	70,265	60,613	66,592
Imperial Economic Botanist	46,037	49,495	53,348
Imperial Agriculturist	1,17,579	1,32,562	1,76,413
Headquarters Total	3,47,251	3,49,987	3,93,594
Sugarcane Station, Coimbatore	90,292	83,157	89,286
Locust Warning Organisation (Headquarters and Field staff).	1,09,647	1,58,129	2,71,120
Total Expert Staff	5,47,190	5,91,273	7,54,000
Experimental Farms—			
Botanical Sub-Station, Pusa	20,244	18,028	24,247
Agricultural Sub-Station Karnal	95,986	91,472	1,04,757
Total Experimental Farms	1,16,230	1,09,500	1,29,004
Total Expenditure	8,86,084	9,09,721	11,16,706

The expenditure of the various Research Scheme financed by the Imperial Council of Agricultural Research during the triennium amounted Rs. ·1,75,903, Rs. ·1,54,332 and Rs. ·2,18,682 respectively as shown below :—

	1941-42.	1942-43.	1943-44.
Development scheme	39,193	42,746	50,466
Botanical Sub-Station	20,244	738	..
Sugarcane Sub-Station	13,727	6,912	7,561
Research on Diseases of Sugarcane	21,751	22,294	17,761
Genetics of Sugarcane	4,449	5,233	3,468
Potato Breeding	13,910	17,937	46,641
Wheat Breeding	6,449	6,613	7,208
Tobacco Breeding Sub-Station	13,230	13,483	16,319
Insect Pests of Sugarcane	42,572	26,804	23,276
Chemistry of Sugarcane	378	3,146	..
Storage of Jowar	..	..	3,644
Physiology of Sugarcane	..	6,220	4,540
Soil Survey	..	2,206	28,245
Type culture of Fungi	..	..	220
Icerya Purchasi	..	..	9,333
Total ..	1,75,903	1,54,332	2,18,682

The receipts of the Institute and its Sub-stations during the triennium amounted to—

	1941-42.	1942-43.	1943-44.
	Rs.	Rs.	Rs.
Main Institute	42,541	47,133	76,986
Agricultural Sub-station, Karnal*	58,644	42,580	1,02,758
Sugarcane Sub-station, Coimbatore	6,309	6,322	8,828
Botanical Sub-station, Pusa	..	1,172	422
Locust Warning Organization	..	..	10,883

* *Vide* Income and Expenditure figures reproduced below :—

Income & Expenditure account for the triennium ended March, 1944—Agricultural Sub-station, Karnal—

	1941-42.	1942-43.	1943-44.
	Rs.	Rs.	Rs.
1. By sale of dairy produce.	16,538	18,378	32,626
2. By sale of Farm produce.	31,504	9,626	61,887
3. Misc. receipts ..	1,166	1,471	1,392
4. Livestock ..	9,436	13,105	6,853
Total ..	58,644	42,580	1,02,758

	1941-42.	1942-43.	1943-44
	Rs.	Rs.	Rs.
1. Pay of officers and Estt.	34,056	34,213	34,295
2. T. A.	280	312	374
3. Dareness allowance.	..	1,679	8,024
4. Feed of Dairy cattle etc.	6,882	8,624	7,619
5. Production of grain & fodder.	27,697	29,522	33,495
6. Workshop ..	1,912	2,000	1,980
7. Fuel, light, water etc.	3,401	3,399	3,397
8. Miscellaneous contingencies.	2,400	3,000	3,504
9. Capital expenditure	636	296	295
10. Repairs to plant & machinery.	16,768	9,013	10,736
11. Petty construction & repairs steam tackle grant.	3,312	103	1,997
Total ..	97,344	92,161	1,05,716

REPORT OF THE IMPERIAL AGRICULTURIST

(C. H. PARR, I.A.S.)

I. AGRONOMY

(*a*) AGRICULTURAL SECTION, NEW DELHI

1. *Seasons and crops.*—The monthly rainfall during the years 1941-42 to 1943-44 was distributed as below :—

Months	1941-42	1942-43	1943-44
June	3·08	1·83	1·35
July	*Nil*	12·54	6·39
August	6·10	5·19	3·04
September	1·75	7·35	4·48
October	0·03	*Nil*	*Nil*
November	*Nil*	*Nil*	*Nil*
December	0·35	0·54	*Nil*
January	0·52	0·32	1·04
February	1·99	*Nil*	2·57
March	*Nil*	0·01	1·84
April	0·91	0·39	1·37
May	0·29	0·69	*Nil*
Total ..	15·02	28·86	22·08

The year 1941-42 was characterised by a light monsoon and low, total rainfall but the winter rains were good and fairly well distributed. Owing to the absence of rain in July, the sowing of *kharif* crops, except sorghum for fodder was delayed till August. On account of the abnormally high maximum and minimum temperatures ruling in October the sowing of the *rabi* crops had to be put back to later dates than usual. Severe frosts on the 10th and 11th January 1942 completely destroyed the pigeonpea crop and did considerable damage to sugarcane. A very heavy and destructive hailstorm on the 15th April 1942 was responsible for 60 to 75 per cent. loss of the grain in wheat, oats, barley and gram crops which were being harvested at the time and although the crops were good, yields in consequence were very poor.

In 1942-43 the monsoon rains were good and well distributed the effect of which showed itself in fairly good yields of most of the *kharif* crops and in a good germination of most of the winter crops. The winter rains were deficient, being only 1·26 inches up to the end of April and some of the winter crops suffered. Light frosts occurred and affected most of the late-maturing varieties of pigeonpeas.

Summer rains were plentiful in 1943-44 and were well distributed. The *kharif* crops, therefore, did fairly well. The months of October, November and December were rainless and only light showers of rain were received during January. The *rabi* crops, therefore, did not do well in the early stages, but later on they improved considerably on receipt of good showers of rain during the third week of February. Inclement weather prevailed from the middle of March to the middle of April and maturity of *rabi* crops was delayed. Owing to the subsequent rapid increase in temperature when the crops were still immature, rapid drying out of the grain and faulty setting ensued. The frequent rains led to tall growing crops and consequently much lodging which reduced the yields.

Extreme shortage of labour at sowing and harvest time was a recurring experience during these three years. The large area of *rabi* crops could neither be sown in time not harvested sufficiently quickly to avoid considerable shedding of grain and consequent reduction in crop outturns. It is necessary that the equipment for sowing and harvesting field crops should be modernised without further delay in order to avoid loss due to shortages of labour which prevail at the seasons. The cost of equipment will be made up quickly by the saving of grain now lost in the field. The methods of harvesting experimental crops in which reliance is placed on hand labour no longer meet requirements. Effective handling of our large experimental programme now demands that the experiments are laid down in a manner which admits of the use of mechanical appliances in the sowing and cultivation, and of machanical means of threshing out the large numbers of small plots involved. The work was carried out under difficulties of shortage of materials and scarcity of labour arising from the war, new implements could not be purchased and spare parts with which to keep old implements at work unobtainable. Much by way of improvisation and make shift arrangements were therefore necessary during the period to enable the work to be carried on.

2. *Seed supply.*—The demand for seeds of improved varieties of crops from different provincial and state departments of agriculture as well as from private individuals continued to increase and has been met as far as possible. The total quantities of seeds supplied in different years were 5921 lb. in 1941-42, 2081 lb. in 1942-43 and 8803 lb. in 1943-44.

3. *Preservation of fodders.*—Sufficient fodder was raised and preserved as silage and hay for cattle. The principal crops turned into silage were sorghum, cowpeas and grasses, while these made into hay were berseem, lucerne, oats and sorghum Analyses of chopped and unchopped material for silage were continued to be made and the results confirmed the previous observations that silage made from unchopped material contained more protein. The main difficulty in this method is that due to high acidity the knives of chuff cutter were more quickly worn out when the crop was cut as silage as compared with, when cut before ensiloing.

4. *Farmyard manure.*—In 1941-42, storing of dung and litter in trenches was continued as in previous years with a view to prevent fly-breeding. In subsequent years only as much dung and litter was stored in the trenches as was requird for experimental purposes, while the bulk of the material was carted straight from the byres to the fields, spread there and ploughed in as soon as possible. This method has proved to be beneficial in two ways. Firstly, it is economical as carting has to be done only once. Secondly, fly-breeding is practically eliminated. Crops of berseem and sorghum were grown after applying fresh dung to the fields and normal yields have been obtained in both the cases.

5. *Work on sugarcane.*—The testing of important Co. varieties of sugarcane was continued. In 1941-42, eighty varieties including fourteen strains received from Coimbatore were planted. The crop was severely damaged by frost in January 1942. The varieties which showed resistance to frost were Cos. 453, 537, 538, 356 & 396 in the order mentioned. In 1942-43, thirty-eight varieties were tested out. In the following year, fifty-seven varieties including eleven new Coimbatore canes were grown. Out-of these, Cos. 545, 537 (Co. K 30), 453, 452, 469 given in order of merit yielded better than the rest. Chemical analyses of the juice of all the varieties were carried out by the Imperial Agricultural Chemist.

6. *Field experiments.*- The main results obtained from the various experiments are summarised below :—

(1) *Manurial experiments.*- (*i*) *To determine the relative values of nitrogen in different organic manures and inorganic fertilizers and the estimation of their recovery by the crops and the changes brought about in the soil* -This experiment was taken up in 1941-42 on the recommnedation of Sir John Russell and is being carried out with the collaboration of the Imperial Agricultural Chemist. It was conducted in the same field and as a continuation of the experiment to study the residual effect of manures described in 1939-40 report, but with a change in the cropping, in the dosage of the manures and in the time of their application. In 1941-42 the manures were applied on the basis of 20 lb. N per acre once in the *kharif* and again in the *rabi* before the sowing of the sorghum and wheat crops respectively. In view of the very low yields of the wheat crop due to double cropping during 1941-42 and 1942-43, no *kharif* crop was grown in 1943-44 and though the yields of wheat crop in this year were considerably improved, no statistical significance was observed among the various manurial treatment effects due to the extreme variability of the soil fertility. It has been decided to start a second series of experiment in a more uniform field from 1944-45 with an increased dose of nitrogen of 40 lb. per acre and with the inclusion of two green manure crops. The results of the chemical analyses of crops and soils will be found in the report of the Imperial Agricultural Chemist.

FIGURES OF CROP YIELDS OBTAINED DURING THE THREE YEARS' PERIOD 1941-42 TO 1943-44 ARE GIVEN IN THE TABLE BELOW :—

Average yields in maunds=(82·3lbs.)-per acre.

Treatment per acre	1941-42		1942-43		1943-44	
	Kharif	Rabi	Kharif		Rabi	Rabi
	Sorghum green fodder	Wheat grain	Sorghum green fodder	Maize green fodder	Wheat grain @	Wheat grain
A. No Manure	257·7	6·45	87·7	133·8	6·97	17·89
B. F. Y. M. at 20 lb. N. ..	264·9	7·44	108·9	164·2	8·13	17·37
C. Activated Sludge at 20 lb. N.	281·9	9·47	172·0	180·6	9·36	17·72
D. Rape Cake at 20 lb. N. ..	296·5	9·45	139·0	179·1	11·54	21·29
E. F. Y. M. at 20 lb. N. plus Am. Sulph. at 20 lb. N. plus Superphos at 20 lb. P_2O_5 ..	278·1	7·66	120·0	158·3	6·90	19·54
F. Act. Sludge at 20 lb. N plus Am. Sulph, at 20 lb. N plus Superphos at 20 lb. P_2O_5 ..	282·7	7·39	167·2	188·7	9·11	17·29
G. Rape Cake at 20 lb. N plus Am. Sulph. at 20 lb. N plus Superphos at 20 lb. P_2O_5 ..	296·4	9·19	140·1	161·3	10·81	19·39
H. Leaf Compost at 20 lb. N. ..	241·4	6·84	156·1	169·4	6·51	13·99
I. Leaf Compost at 10 lb. N plus Am Sulph. at 10 lb. N plus Super to make up 20 lb. P_2O_5	286·6	9·08	121·1	165·0	7·85	19·48
J. F. Y. M. at 10 lb. N plus Am. Sulph. at 10 lb. N plus Super. to make up 20 lb. P_2O_5 ..	290·2	9·12	171·3	154·2	9·30	20·19
K. F. Y. M. at 60 lb. N. ..	301·7	9·77	150·5	186·9	9·70	18·41
L. Am Sulph. at 20 lb. N plus Super. at 20 lb. P_2O_5 plus Pot. Sulph. at 20 lb K_2O	294·0	10·20	168·3	203·6	11·37	17·98
z test		Sig. at 1% level.	Not Sig.		Sig. at 1% level.	Not Sig.
Critical diff. (5%)		26·46 1·56	67·54		2·47	3·78
C. V.		8·11 15·79	20·90		18·40	17·71

@ Excluding the yields from two blocks which were kept fallow in the *kharif*; Sorghum and maize were sown in two blocks each in the same year.

(*ii*) *Manurial experiments with berseem.*—An experiment was started in 1940-41 to study the differential effects of various manures on the production of berseem fodder and seed and the residual effect on the succeeding fodder crop of cowpeas. The experiment was repeated for two consecutive years on the same plots with manured berseem in the *rabi* and unmanured cowpeas in the *kharif* and has provided evidence of a definite response of the berseem crop to phosphatic manuring in regard to fodder production as well as to the recovery of phosphoric acid and calcium in the fodder. The yield and the extent of recovery of P_2O_5 and CaO increased with increased doses of superphosphate. In *kharif* 1943, cowpeas was grown in 4 blocks of the field and the remaining two blocks were kept fallow. Wheat was grown in the following *rabi* in all the blocks without any further manuring. The yields of wheat in the fallow-wheat rotation were higher than those obtained in the cowpea-wheat rotation, but the trends of variation due to residual effects were the same in both the rotations—the yields increased with the increased amount of phosphate added to the berseem crop whereas sulphate of ammonia which had depressed the yields of berseem also gave very low yields of wheat.

In a second experiment started in 1941-42, where lower doses of phosphates were used, the yields of berseem fodder increased with increasing doses of phosphates. This experiment has also been carried out for three consecutive years and it is proposed to grow unmanured wheat in the next *rabi*.

The residual effects of the manures applied to berseem in both the experiments did not produce in cowpeas responses of the same order as were shown in berseem Two articles on " Phosphatic manuring of legumes " published in *Indian Farming*—April 1944 and May 1945 issues give full details of results obtained from these experiments.

(*iii*) *Manurial and cultural experiment with lucerne.*—The experiment which was started in 1940-41 was continued till 1942-43. The factors under investigations were (*a*) phosphatic manuring in different doses, (*b*) different methods of sowing and (*c*) different types of intercultural operations. Higher yields were obtained in 1941-42 with the higher dose of fertiliser, but this was not maintained in 1942-43. The broadcast crop gave better yields than the crop which was sown in rows and the intercultural operation done with a cultivator followed by sub-soiler produced the highest yield of lucerne.

(*iv*) *Phosphate manuring of other legumes.*—The possibilities of improving the yield of legumes by phosphatic manuring and at the same time of increasing the fertility of soils were investigated during the years under report. Peas—both field and garden varieties responded to phosphate manuring and the succeeding crop of unmanured maize gave higher yields in the plots following phosphate manured peas than in the unmanured plots. Cowpeas, soybean and gram did not respond significantly to phosphate manuring. Further experiments are being conducted with these and other leguminous crops.

(*v*) *Manurial trials with paddy.*—A complex manurial varietal trial with paddy was conducted at Karnal during the years under report to see the manurial effects of sulphate of ammonia and nitrate of soda alone and in combination on three I. P. paddy strains. Sulphate of ammonia alone and in combination with nitrate of soda gave higher yields than nitrate of soda. The differential response of varieties to manures was not significant.

(*vi*) *Technique of green manuring.*—A series of experiments were conducted both at Delhi and Karnal to examine the effects of leguminous and non-leguminous green manure crops grown *in situ* and brought from out side both with and without the application of fertilizers on the yields of wheat. Of the legumes, cowpeas and sunnhemp, have shown up better than the non-legumes such as sorghum and maize. Non legumes gave better results when they were brought from outside than when grown *in situ*, but the reverse was the case with legumes. Addition of fertilizers, notably sulphate of ammonia gave increased yields of wheat.

(*vii*) *Comparative field experiments with pit-stored, anaerobically prepared and sun-dried farmyard manures.* These experiments are in progress since 1942-43 in collaboration with the Imperial Agricultural Chemist to see the effect of the above manures on wheat. So far, anaerobically prepared manure has given better results than the other manures.

(2) *Cultural and rotational experiments*—(*i*) *Date of sowing experiment with gram.*—This experiment started in 1938-39 again confirmed the previous finding that gram must not be sown early *i.e.* in September due to its high susceptibility to wilt. Late sown crops showed better yields and a lower incidence of wilt. In 1942-43 a new treatment of vernalising the seed was introduced. The idea was to see whether by bringing in early maturity, the ravages of late wilt could be minimised. No promising results have been obtained.

(*ii*) *Date of sowing experiment with berseem.*—Under Delhi conditions, the middle of October has been found to be the best time for sowing berseem for seed production.

(*iii*) *Rotation experiments with berseem.*—The best yield of berseem fodder was obtained in the plots in which sunnhemp had been raised and ploughed down as green manure and the worst in those preceded by a crop of sorghum. The experiment was conducted for three years from 1941-42 to 1943-44.

(*iv*) *Tillage experiments at Karnal.*—This experiment was started in 1942-43 to study the relative merits of tractor ploughs and bullock drawn iron (inversion) and country ploughs (non-inversion) for seed bed preparation for wheat. The two years' results showed the superiorit of tractor ploughing over the others.

(3) *Mixed farming experiments.*—These long term experiments have been laid out at Karnal and Delhi to ascertain how farming operations need to be adjusted, so that animals support the fertility of the land, and the land provides efficient maintenance for the animals, and operating together they provide for the farmer a surplus of food and crops and dairy produce for his cash requirements. At Karnal the experiment was conducted under (*i*) Large-Scale holding under mechanised farming on 400 acres, (*ii*) small scale holding on 25 acres and (*iii*) small scale holding on 8 acres. At Delhi, it is being conducted on a 8-acre holding only. Two small holdings of 8-acres and 7·5-acres are also being run at Delhi to see the effect of 50% and 66·6% intensities of green manuring.

(4) *Flood water farming experiments.*—Experiments, have been undertaken at Delhi and Karnal to study the possibilities of increasing the crop area and ensuring crop production in those areas in Northern India where vast areas of cultivable land have to be left unsown due to insufficient rain and insufficient quantities of irrigation water, which is in great demand for *rabi* crops in October and the following months. If the surplus water in the rivers during the monsoon could be used to make up deficiencies in rainfall by flooding land during August or September, it might be possible to ensure regular *rabi* crop rproduction in these precarious areas. Two articles were published on this subject in *Indian Farming*, March and October issues of 1943 giving the results of the first two years' experiments.

Average yields of grain for the three-year period 1941-42 to 1943-44 in these experiments are given below :—

Average yield in maunds (82·3 lb.) per acre.

Locality	Flooding	Wheat		Barley		Gram	
		Mulched	Non-mulched	Mulched	Non-mulched	Mulched	Non-mulched
Delhi ..	Flooded in August	1·66	2·28	6·31	7·99	5·10	5·16
	Flooded in September.	7.04	6·43	18·02	18·67	8·53	7·14
	Rainfed only ..	5·98	5·78	17·45	13·37	5·66	4·72
Karnal ..	Flooded in September.	17·30	13·30	23·11	22·61	16·77	16·40
	Rainfed only ..	10·93	7·99	17·58	13·62	9·69	9–54

The monsoon (June to Sept.) and winter (Oct. to March) rainfalls recorded at Delhi and Karnal are given below :—

		1941-42	1942-43	1943-44
Delhi	Monsoon	10·93	26·91	15·26
	Winter	2·89	0·87	5·45
	Total for the year ..	15·02	28·86	22·08
Karnal	Monsoon	16·74	32·71	17·25
	Winter	17·52	2·43	3·21
	Total for the year ..	25·25	36·62	22·99

The low rainfall year of 1941-42, when September flooding showed its value, the wheat and barley crops at Delhi were destroyed by hailstorm just before harvest. As the yields in this year which reflected clearly the effect of September flooding, could not be included, the difference shown in the table for Delhi is less than the expected value.

(5) *Artificial mulching experiments :* These experiments were continued both at Delhi and Karnal since 1941-42 with a view to increasing sugarcane yields by preventing the rapid evaporation of soil moisture by using crop residues such as sugarcane trash. Significant increases have been obtained in the yields of sugarcane and also in gram, wheat and barley in flood water farming experiments where artificial mulching has been used.

(6) *Fodder grasses.*—With a view to testing indigenous grasses for fodder and pasturage, living specimens and seeds of grasses were collected from the different provinces and states in 1942 and 1943 and grown in a nursery plot at Delhi. About 80 species so far have been identified and they are being grown in larger plots for detailed study. Further additions to this collection are being made.

(*b*) AGRICULTURAL SUB-STATION, KARNAL

1. *Seasons and crops.*—The figures of monthly rainfall for the years 1941-42 to 1943-44 are given below :—

Months	1941-42	1942-43	1943-44
June	5·50	3·88	2·49
July	3·80	16·10	7·26
August	6·01	8·74	4·21
September	1.43	3·99	3·29
October	Traces	*Nil*	*Nil*
November	*Nil*	*Nil*	*Nil*
December	0·22	0·47	*Nil*
January	2·54	1·62	0·96
February	4·56	0·15	1·63
March	0·20	0·19	0·62
April	0·77	1·48	2·33
May	0·22	*Nil*	*Nil*
Total ..	25.25	36.62	22.79

In 1941-42, though the rainfall was better than that of the previous year, it was not well distributed and not conductive to increased yields of crops. The yields of major *rabi* crops were better than in the previous year, although bunt was responsible for some damage in almost all the varieties of wheat. Frost in January 1942 was responsible for the destruction of all late maturing pigeon-pea varieties. In 1942-43, heavy precipitations adversely affected the yields of both *kharif* and *rabi* crops. Considerable damage was done to gram by wilt. All the varieties of wheat were more or less free from bunt and smuts, with the exception of I. P. 111, which was slightly affected with smuts. In 1943-44, the rainfall was below normal. The continuous rain during July hampered the *kharif* sowing. Most of the rain in September was received in the very beginning of the month which prevented a large area being put under gram. On a mechanised farm where large scale manuring is not possible good yields depend on effective and timely cultivation. This was unfortunately not possible due to the unsatisfactory condition of machinery for want of spare parts.

2. *Seed supply.*—Seed multiplication of I. P. varieties and seed distribution to the different provinces and states is one of the important activities of the substation. The total quantities of seeds supplied in different years were 203,828 lb. in 1941-42, 2,141 lb. in 1942-43 and 53,660 lb. in 1943-44. In 1942-43, the distribution of seeds had to be limited due to the transfer of surplus grains to Delhi.

3. *Field experiments.*—The results of the more important field experiments have already been considered in the previous section of this report.

4. *Usar control.*—The paddy-berseem rotation was continued in Plot No. 7 where *usar* patches are common. In the kharif the paddy crop usually covers them, after which they are less conspicuous in the *rabi* berseem crop. Where water is available, this rotation enables effective use to be made of such soils. Since 1942-43, another method for the reclamation of *usar* has been adopted. In this method alkali

patches are covered with paddy straw. Analyses of soil samples made by the Imperial Agricultural Chemist show that artificial mulching considerably checks the rise of salt to the surface.

5. *Compost making.*—The preparation of compost was continued on the lines given in the report of 1939-40. In 1943-44 dung and litter were carted direct to the fallow fields and the *kharif* crops grown on such plots showed a vigorous growth. The cost of manufacturing compost per maund (82·3 lb.) worked out to 6·75 pies in 1941-42, 7·87 pies in 1942-43 and 10 pies in 1943-44.

6. *Machinery and implements.*—The Fowlers' steam ploughing tackle was worked sparingly as the engines have become very old and certain parts which require replacement are not available at present. The two old McCormick Deering tractors W. D. 40 and the new tractor purchased in 1940 were worked throughout the period under report. Owing to a large sum spent on repairs and renewals in the old tractors the cost of working was higher than with the new tractor. The running cost per hour varied between Rs. 8·13 and Rs. 3·23 during this period, while in the case of the new tractor it varied between Rs. 4·18 and Rs. 3·27 per hour. The threshers worked satisfactorily throughout the period.

II. CATTLE BREEDING.

Delhi and Karnal.

1. *Herd Strength.*—The herds consisted of the undermentioned number of animals in the three years under review :—

	Sahiwal herd Delhi			Tharparkar herd Karnal		
	On 30th June			On 30th June		
	1942	1943	1944	1942	1943	1944
Breeding bulls	13	12	13	14	13	11
Milch Cows	91	85	89	91	79	92
Young male stock	51	78	76	57	44	78
Young female stock	74	80	89	83	100	88
Total ..	229	255	267	245	236	269

2. *General health.*—In the Sahiwal herd there was an outbreak of foot and mouth disease during the latter part of May 1941 which continued for about two months and had a depressing effect on the milk yield. Otherwise the herd maintained a high standard of health and condition throughout the period under report.

In the Tharparkar herd the general condition and health remained satisfactory except a few cases of Haemorrhagic Septicaemia in 1941-42 and three-day fever in 1942-43. Every year the herd was inoculated against Rinderpest and Haemorrhagic Septicaemia and against Black Quarter in 1943-44.

3. *Milk yields.*—Figures for milk yields and for the number of cows in milk are given below :—

	Sahiwal herd.			Tharparkar herd.		
	1941-42.	1942-43.	1943-44.	1941-42.	1942-43.	1943-44.
Wet average (lb.)	20·0	19·7	21·6	20·1	22·2	21·4
Overall average (lb.)	12·1	13·4	15·7	15·5	14·3	16·2
Total No. of milch cows per day	88	79	82	89	89	87
Percentage of cows in milk ..	59·4	67·4	72·5	76·3	76·0	75·0
Average yield per lactation for the whole herd. (lb.).	5960	5094	6687	5071	5928	6511
Average No. of days in milk	283	274	299	283	284	296

4. *Early maturity experiments.*—These experiments were continued on the lines given in previous reports. In the Sahiwal herd in 1943-44, the heifers were mated at an average age of 1 year, 6 months and 27 days at an average body weight of 640 lb. The average yield of such heifers was 5536 lb. in 303 days. In the Tharparkar herd in 1941-42 the average age at first service was 1 year 9 months 9 days with an average body weight of 643 lb. The average milk yield was 5363 lb. in 298 days. The offspring of early maturity heifers and bulls were normal in all respects.

5. *Record yields of cows and heifers.*—In the Sahiwal herd ' Chansuri ' gave a total yield of 12,312 lb. of milk in her sixth lactation, ' Bilamba ' gave 11,290 lb. and 11,320 lb. of milk in her fifth and seventh lactations respectively, ' Birengee' yielded 10,413 lb. in her seventh lactation and ' Tamili ' gave 10,005 lb. in her second lactation. Among heifers ' Tahskam ' and ' Shakbila ' gave 8621 lb. and 7, 171 lb. of milk respcetively. In the Tharparkar herd ' Phijji ' and ' Qairahmi ' gave over ten thousand pounds of milk in their third lactations. Among heifers ' Ramuni ' gave 8263 lb. and ' Qaisrami ' , ' Qairahmi ', ' Mago ' and ' Ranbina ' gave over seven thousand pounds of milk in their first lactation. All these yields were recorded for fixed lactation period of 306 days.

6. *Calf rearing.*—At Delhi and Karnal all calves were reared on milk standardised to 3·5% fat with skim milk on a weekly scale based on one-tenth birth weight for a period of two months. The mortality among pail-fed calves at Delhi ranged from 7·8 to 11·5% and that of Karnal from 11 to 24·5%. The chief causes of death at Delhi and Karnal were calf penumonia, naval ill and dysentery.

7. *Sale of cattle.*—There was a great demand for both cows and bulls from the two herds and the surplus stock was sold to government and private institutions and to the public. A few orders were also received from foreign countries.

III. PROGRAMME OF WORK FOR THE YEAR 1944-45.

Work will be continued on the lines in progress described in the present report. More comprehensive experiments will be started to test the results obtained with berseem using various legumes and phosphates in different forms and in combination with other manures.

IV STATISTICAL BRANCH

(P. V. KRISHNA IYER)

(*a*) DAIRY DATA.

(*i*) *Investigations of a general nature.*

Suitability of orthogonal polynomials for representing weekly milk yield.—The efficiency of ordinary and logarithmic curves and the suitability of the efficient curve for representing weekly milk yield were examined by finding the residual errors and the co-efficient of variation for the weekly milk yield of a few cows belonging to the Sahiwal breed. Ordinary curves were found to be more efficient than logarithmic ones.

Comparison of polynomial constants for lactation curves of cows of the same and different breeds of cows.—Significant differences between the polynomial constants have been observed between the same lactation curves of cows belonging to the same and different breeds.

Lactation curves for the Sahiwal cow Chengee and some of her progenies.—Comparing the average yield per week, out of the three daughters of Chengee only one daughter Birengee, yielded better than her mother. Baleswari, an elder full sister of Birengee did not yield even up to the level of her mother. Birengee had four daughters, Chirangee, Lakarengee, Erengee and Rajarengee from Chaplain, Lakhan, Emden and Rajad respectively. The performance of all the four daughters did not reach the level of either their dam or grand dam.

The increases in yield in the different lactations varied from cow to cow. There was some similarity in the increase in yield in the different lactations of Chengee and Birengee only.

The average rate of decrease in milk yield differed from lactation to lactation and from cow to cow. It was low for the first lactation and increased for the other lactations.

Comparison of polynomial constants for morning and evening weekly milk yield, fat % and total fat.—The differences between the constants for morning and evening were not significant for either milk yield or fat. The total fat and the milk yield showed a steady decrease with the advance in lactation. The rate of decrease or the percentage rate of decrease (b/mean X 100) was more for milk yield than that for fat.

Correlation between milk yield, temperature and humidity.—The correlation co-efficient between the deviations in milk yield and the deviations of (1) maximum temperature and (2) humidity at 8 A.M. after making allowance for the time factor shows that the influence of temperature and humidity varies from animal to animal. There is a general tendency for the yield to go down as the temperature increases. No such marked tendency is seen in the case of humidity.

(*ii*) *Examination of the dairy data for the period 1932-42.*

In April 1932 four times milking and early maturity experiments were started in the dairy herd at the Institute. These experiments are still in progress. The statistical analysis of the data collected during the years 1932-42 was done and the results are very briefly summarised below :

Age at first calving.—The average age at calving of the initial cows and their first and second progenies is $31\cdot0\pm0\cdot46$, $29\cdot0\pm0\cdot30$ and $29\cdot2\pm0\cdot51$ months. It will be seen that calvings in the first and second progenies were taking place two months earlier than in the case of initial cows. This difference was not maintained in the succeeding calvings.

Rate of growth of cows from birth to seventy weeks.—The average triweekly rate of growth for the first twenty five weeks varies from $20\cdot5\pm0\cdot56$ to $24\cdot3\pm0\cdot58$ lb. In the second 24 weeks the variation in the rate of growth is $24\cdot3\pm0\cdot94$ to $28\cdot1\pm0\cdot74$ lb. For the third 24 weeks this varies from $18\cdot7\pm0\cdot93$ to $20\cdot6\pm0\cdot51$. It will be noticed that the rate of growth is in general more in the second 24 weeks than in the preceding and succeeding periods.

Weight of cows at service and at calving.—There is no significant difference between the weights of cows of the various progenies at first, second, third etc. services. However the weight varies from 630 to 666 lb. in the first service, in the second service this varies from 775 to 797 lb., in the third from 846 to 863 lb. and in the fourth 900 to 940 lb. The average weight at different calvings varies from 795 to 814 lb. in the first calving, 880 to 922 lb. in the second calving, 946 to 1,015 lb in the third calving and 952 to 1,012 lb in the fourth calving. The difference in the weights between the various progenies at different calvings is not significant. It has already been mentioned that the cows of the first and second progenies were maturing two months earlier than their progenies. But the difference in weight at calving is not significant. This shows that weight is a more reliable criterion of maturity than age.

Total milk yield.—The total yield for the different progenies during 1932-42 varies from $4077\pm251\cdot7$ lb. to $7766\pm534\cdot4$ lb. in the different lactations. The general increase in the yield by four times milking and early maturity experiments is about 60%.

Wet average yield per cow per day.—The wet averages of the heifers show steady increase from $14\cdot75\pm0\cdot76$ to $17\cdot81\pm0\cdot98$ lb. from progeny to progeny. The averages in the second and third lactations vary from $18\cdot69\pm1\cdot16$ to $24\cdot44\pm2\cdot85$ lb. It will be seen that the yield of the heifers has increased from progeny to progeny. In the case of adults the yield has practically remained at the same level in the different progenies.

Overall average yield per cow per day.—Like the wet averages, the overall averages also show steady increase from progeny to progeny in the 1st and 2nd lactations only. The difference between the yields of the 1st and 2nd progenies in these lactations is not significant. In the 1st and 2nd lactations the overall averages increase from $9\cdot43\pm0\cdot64$ to $12\cdot75\pm0\cdot97$ and $11\cdot72\pm0\cdot67$ to $15\cdot83\pm1\cdot02$ lb. In the other lactations it varies from $13\cdot82\pm0\cdot62$ to $16\cdot76\pm1\cdot19$ lb.

Wet period.—It is the general practice in the dairy to milk the cows for 306 days as far as possible, but some of the cows dry up earlier. Excepting the second lactation of the second progenies there has been considerable fluctuation in the wet period in the different lactations of the various progenies.

Service period.—The range in the average service period is 110 to 163 days.

Correlation between weight at calving and wet average milk yield.—The average yield per day appears to depend on the weight of the cows to some extent in the first and second lactations. The correlation coefficients for the first and second lactations are 0·245 and 0·274 respectively.

Correlation between increase in weight from service to calving and milk yield.—In the second and third lactations, as the cows put on more weight from service to calving the average yield also increases. The correlation coefficient between the average milk yield and increase in the weight of cows from service to calving in the second and third lactations are 0·352 and 0·381.

Correlation between milk yield, service period and wet period.—The average yield is more for cows for longer service and wet periods in the first and second lactations.

Daughter-dam-grand-dam comparison of milk yield.—As has already been seen, a careful study of the wet averages on daughter-dam basis shows that the improvement in the yield is seen in the first lactation of the first progeny only. The cows Durkhi, Lardhi, Lagati, Labina, Bansuri, Cholmi, Chamati, Chamba, Madrama and Rajmohni have given as much milk, if not more, than their dams and grand-dams.

Milk yield from bull point.—The bulls Lakhan, Firad and Nala appear to have some capacity for transmitting milk to their progenies. The increase in the yield has been seen only in the first lactation.

Correlation between the average milk yield of the daughters, dams and grand-dams.—None of the correlations is significant. This indicates that the genetic variation of the herd as compared to the variation due to other causes is insignificant.

Correlation between the rates of growth of the dam and the daughter.—The correlation coefficient between the rates of growth of the dams and daughters after removing the effect of variance and covariance between the bulls is not significant. This also shows that the genetic variation of the herd as compared to the variation due to other causes is not significant.

Health of cows during 1932-42.—The number of cows showing symptoms of Johne's disease was 31 in the case of initial cows and 14 and 5 in the first and second progenies. These figures show that probably due to heavy strain on the animals there was some deterioration in the herd in the beginning but later on by elimination, by careful management and by proper feeding the position has considerably improved.

(*b*) DYNAMOMETER TESTS WITH PLOUGHS.

Effect of ploughman, bullocks and moisture etc. on draw-bar-pull.

(*i*) The draw-bar-pull did not appear to depend on the skill of the ploughman.

(*ii*) The pull required to plough a stubbled land was more than that for a fallowed plot.

(*iii*) The Hariana bullocks took less time than the Sahiwal or the Malvi to do speed of the same amount of work.

(*iv*) The draw.bar-pull did not appear to be in any way connected with the bullocks.

(*v*) The draw-bar-pull was a minimum when the moisture in the soil was 11·25% on wet basis.

(*vi*) A plough has been found to work smoothly and efficiently when the angle between the beam and wedge is between 40° and 50°.

(*c*) INFLUENCE OF IRRIGATION ON THE WATER LEVEL OF WELLS

The water level of wells is affected to a considerable extent by rainfall and irrigation. If water flows through a water channel, situated at a distance of half a furlong from the well, for more than 4½ days in a period of fifteen days the level of water in the wells of the Institute begins to rise.

The level of all the wells in the Institute has risen steadily in the years 1942, 1943 and1944 due to heavy irrigation and well distributed rainfall in successive years.

C. REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(DR. B. P. PAL)

I. STUDY AND IMPROVEMENT OF INDIAN WHEAT (*Triticum* Sp.)

1. *Survey of Indian Wheats.*—The study of 1056 samples of wheat collected in 1940-41 from all parts of India, was continued and detailed observations were made on morphological and other characters. A set of 220 varieties was grown in 1942-43 and 1943-44 simultaneously at New Delhi, Pusa and Coimbatore to study their behaviour when cultivated under such sharply contrasting conditions of soil and climate. At Simla, the study of the collection of hill wheats was continued.

2. *Description and registration of commercially important varieties and those of special interest for plant breeding.*—The work was started in 1940-41 with the Imperial Pusa wheats and later on such samples as were received from the various Departments of Agriculture were also taken up. In 1942-43, 29 new samples were added to the collection. All these samples received for registration were described in respect of nearly 25 characters, following the standard schedule laid down for the purpose. The description of the Imperial Pusa wheats having been completed for the third year in succession, the data pertaining to these are being prepared for publication.

3. *Study of wild and cultivated wheat species and allied plants.*—Wild plants are frequently more resistant to diseases and to adverse conditions than their cultivated relatives. The object of the present study is to obtain knowledge regarding the less well-known cultivated wheat species, wild wheat species and of species of other generallied to wheat, and to exploit the possibilities of utilising these for the amelioration of the wheat crop. In this connection, a collection of almost all the wheat species and of such grasses as *Agropyron*, *Aegilops*, *lolium*, *Leptures*, etc., allied to *Triticum* is receiving attention. Crosses between these and the cultivated wheat species were being made and the following intergeneric hybrids were subjected to cytogenetical study : F_3 *T. vulgare* X *Secale cereale*, F_3 *T. vulgare* X *Ae. caudata*. The F_1 plants of *T. dicoccum* X *Ae. ventricosa*, *T. Timopheevi* X *T. monococcum* and *T. aegilopoides* X *T. dicoccum* were under observation, all the three proved to be completely sterile.

The mode of inheritance of the branched ear character and several other characters was investigated in crosses of *T. Vavilovi* with *T. vulgare* and *T. sphaerococcum*.

A large number of new interspecific and intergeneric crosses was attempted both at New Delhi and Simla.

4. *Experiments on smut resistance.*—The object of this work which is being carried out in collaboration with the Section of Mycology and Plant Pathology, is to test varieties and new fixed hybrids for resistance to the smut diseases of wheat and to unite smut resistance with other desirable characters. A number of strains prove to be resistant to loose smut. The progeny from a double cross was tested in 1942-43 simultaneously for resistance to loose and flag smut.

5. *Breeding for rust resistance.*—Progress was made in this work which is being carried out in collaboration with Dr. K.C. Metha with a view to synthesising varieties resistant to yellow, brown and black rusts and with good agronomic characters. Tests

of varieties and hybrids for both seedling and adult resistance were carried out at Simla* and for adult resistance only at New Delhi. A large number of crosses between the best cultures resistant to the brown and yellow rust respectively were under study. In order to evolve varieties which would unite resistance to all the three rusts, a double cross has been made on a large scale, utilising the best of the brown and yellow rust resistant hybrids, and also a *vulgare* variety from Kenya which is highly resistant to black rust.

6. *Miscellaneous.*—At the request of the Director of Agriculture, Baluchistan, a study of the wheats of that area was taken up since 1940-41, with the object of finding or breeding varieties suited to its climate and soil. Bulk samples were analysed and 70 cultures were isolated. A set of 12 cultures was also grown with the co-operation of the Director of Agriculture, Baluchistan, at places representative of several wheat growing tracts and suitable selections were made and used in hybridization work.

II. BREEDING FOR DISEASE RESISTANCE AND OTHER QUALITIES.

1. Potatoes (*Solanum tuberosum* L. and *Solanum* Sp.).—The general aim of the work on this crop is the production of varieties specially suitable for Indian conditions. A number of hybrids derived from crosses between commercial varieties of *S. tuberosum* were under yield trial at hill stations in various Provinces and States and gave promising results. The study of the commercial varieties of *S. tuberosum* was completed and the results written up for publication. At Simla* the collection of South and Central American species and hybrids was maintained and further studied with regard to their photoperiodic reaction and disease and frost resistance. Suitable crosses were made between *S. tuberosum* and other species. The breeding of late blight resistant varieties was continued with the co-operation of the Imperial Mycologist. By back-crossing hybrids of *S. tuberosum* X *S. demissum* with the cultivated species, particularly, ' Gloriosa ' received from Russia, some resistant forms possessing good tuber shape and high yield have been obtained and these will be further tested. In connection with breeding varieties resistant to virus diseases, well known resistant varieties like ' Imperia ' and ' Craig's Defiance ' were used in crosses with the cultivated varieties and promising progenies have been obtained. The work on frost-resistance was continued with crosses between *S. tuberosum* and *S. curtilobum*. An intermediate Hill Station at Bhowali was established during the year 1943-44 for multiplication of the new varieties.

2. Pigeon-Pea (*Cajanus Cajan* L. Millsp.).—The work of testing and selecting wilt resistant strains from among the progenies of the cross I.P. 24 X I.P. 51 was continued at Delhi and Pusa with the co-operation of the Imperial Mycologist. Some cultures have shown a high degree of resistance to the wilt. Resistant cultures will be further tested.

3. Linseed (*Linum usitatissimum L.*).—The selection of strains resistant to linseed rust (*Melampsora-Lini*) from crosses between I.P. strains and resistant exotic types was continued at Delhi and Karnal. In the year 1943-44 ten of the more promising cultures were multiplied at Pusa where all but one culture remained free from rust attack, incidence of which was heavy, whereas all the I.P. types and other hybrids were badly infected. At Karnal, where incidence of rust was moderate,

*At the Potato and Wheat Breeding Sub-Station, Simla, financed by the Imperial Council of Agricultural Research.

only two out of the 130 rust resistant cultures were slightly infected, all others being free from it. All the I.P. types and hybrids under distribution were badly attacked. At Delhi, incidence of rust was unusually heavy during the year (1943-44) and some of the rust resistant cultures, which were observed to be free from the attack at Pusa and Karnal, were slightly affected. This again indicates the possibility of there being two or more physiologic forms of the rust fungus in India. The work of testing these strains under conditions of artificial infection, using samples of rust from several places in India, was continued at the Rust Research Laboratory, Simla, with the co-operation of Dr. Prasada.

Dual-purpose strains from linseed-flax hybrids were grown at Delhi and Pusa. At Delhi the material was retted and fibre extracted for technological valuation by experts.

4. TOBACCO (*Nicotiana* spp.).—The severe frost in January 1942 (minimum temperature = 28·3°F.) destroyed all tobacco standing in the open except four species which were immune to frost and three other species which showed but slight damage. Crosses were made between some of these and the commercial varieties of *N. Tabacum* and the F_1s were grown at Simla. Conclusive results were not obtained as the plants had not made sufficient vegetative growth before the onset of cold weather.

Taking advantage of the good collection of *Nicotiana* species built up in the Section, experiments for assessing the relative resistance of the species to the attack of *Orobanche* were taken up. The species were grown in lines at Delhi, Pusa and Guntur in Orobanche infested fields for study of their reaction to the parasite. The tests have shown that all the species are more or less susceptible to the attack of the parasite but that some of them withstand the attack better than others.

Single plant selections were made in the progeny of crosses originally effected with the object of combining high yield of cured leaf with high nicotine content.

Experiments conducted over a period of three years at Guntur have shown that the deterioration which was said to occur as the result of using acclimatised seed does not occur if the seed is kept pure and that large sums of money need not be spent on importing fresh seeds from America every year or every two years as used to be done before. This finding has been followed by immediate practical application and virginia tobacco seed is now being successfully multiplied in India. Preliminary trials with the newly selected strain Amarelo No. 5, selected at the Sub-Station have given encouraging results in Orissa and Hyderabad. Further trials with the strain are being arranged. The experiments to study the effect of various manures, and combinations of manures and also of crop rotation, on the quality of cigarette tobacco leaf were continued. Several of the manurial treatments have given good results.

III. CYTOGENETICAL STUDIES IN THE OLEIFEROUS BRASSICAE.

1. Classification : The large number of types of the cultivated *Brassicae* collected from all over India were under study from morphological, genetical and cytological stand-points and final classification of these into species and varieties has been drawn up. The variability of characters within and between species has been worked out and a key for identification made. The origin of one of the cultivated species, *B. juncea* (2n=36) has been experimentally demonstrated. The species has actually been synthesised by crossing *B. campestris* (2n=20) and *B. nigra* (2n=16) and later doubling the chromosomes of the sterile hybrid with colchicine.

2. Genetical studies : The study of inheritance of self-sterility in Toria (*B. campestris*) was continued and the presence of two series of allelic factors governing the inheritance of this character was tentatively established.

The apetalous mutant character, which appeared to be a monogenic recessive, was found to give aberrant ratios in the F_2 and back-cross progenies. Cytological examination of F_1 plants showed the presence of inversion bridges at anaphases I and II and the consequent abortion of a certain percentage of pollen. Genetical studies to determine the mode of occurrence of apomixis have shown that a reduced cell in the empryo sac (most probably the egg) develops parthenogenetically with ensuing diploidy. Results of both these studies are so far inconclusive and further work on them is in progress.

3. Artificial induction and study of polyploidy : Tetraploids has been successfully induced in the several cultivated species of mustards, namely, *B. nigra* (2n=16), *B. campestris* (2n=20), *B. juncea* (2n=36) and *Eruca sativa* (2n=22) and large populations of tetraploids were grown and studied for their growth, fertility and other economic characters compared to their corresponding diploids. The tetraploids in every case were more vigorous than the diploids and had bigger flowers, pollen, pods and seeds. Although pollen fertility in the tetraploids was as high as in the diploids (98—100%) the seed-setting was variable in the different plants. In the case of *Toria* (*B. campestris*), where a large number of tetraploid cultures was grown, the seed-setting of individual plants was studied. It was found that the percentage setting (number of seeds per pod expressed as a percentage of the number of ovules formed) varied from 5 to 100. Tetraploids with varying percentages of setting and the progenies produced by them were cytologically studied and were found to be similar, they formed almost a similar number of quadrivalents at meiosis and gave rise mostly to tetraploid progenies. This fact of the similarity of meiosis in these plants and the production of tetraploid progenies by them suggests that the variable setting among them is due to segregation of genes for seed-fertility and that it is possible to fix tetraploids with full fertility by repeated selection.

Although the seeds of tetraploids are about $1\frac{1}{2}$ times heavier than those of the diploids, their oil content (expressed as percentage on dry basis) is found to be almost the same in the two cases.

Further work on the isolation and study of fertile plants from among the tetraploids of the different species will be continued with the object of producing superior strains. There are indications that fertility of these plants could be improved by selection.

IV. FUNDAMENTAL CYTOGENETICAL RESEARCH.

1. Colchicine-induced polyploidy in crop plants : Progenies of tetraploids in gram and chilli were grown and further studied with regard to morphological and physiological characters and selections for improving their fertility were made. The chillies were grown at Pusa, Simla and Guntur also. While the tetraploids have retained their gigas nature they have not substantially improved in fertility inspite of repeated selection for fertility. The tetraploid grams were found to be as susceptible to wilt as the diploids and owing to heavy incidence of the disease in the previous years it has not been possible to multiply the seeds of these tetraploids for trial in other centres.

Tetraploids were induced by colchicine in *Sesamum orientale* and in a sterile interspecific cross, *S. orientale* (2n=26) X *S. prostratum* (2n=32). Tetraploid branches of *S. orientale* obtained by treatment of vegetative buds had bigger pollen. Unlike chilli and gram tetraploids the sesamum tetraploids possessed a very high percentage of good pollen. The seeds of the tetraploids were bigger than those of the diploids. The completely sterile hybrid between *S. orientale* and *S. prostratum* turned fertile on treatment with colchicine and produced many capsules with a good number of seeds. These seeds were bigger than those of either parents. The seed gave rise to true breeding vigorous hybrids combining the character of the two parents. The amphidiploids in spite of regular meiosis produced varying amounts of sterile pollen and showed variable setting.

Seeds of the F_1 hybrids of *N. Glauca* (2n=24) X *N. plumbaginifolia* (2n=20) were treated with colchicine. One of the resulting plants was found to contain the amphidiploid chromosome number, *viz.*, 2n=44. Pollen meiosis in this amphidiploid was again normal, but in spite of this, it was practically wholly male-sterile. It, however, set a fair amount of capsules when back-crossed to the parental species. In this case also the cause, nature and extent of male and female fertilities are under investigation.

2. Collection and study of wild relatives of cultivated plants : The importance of plant introduction to breeding has now shifted from whole plants to genes. Apparently economically useless plants may contain certain useful genes such as those for drought-or disease-resistance, which if properly handled and bred into commercial varieties would result in considerable improvement of the existing strains. With this object in view, wild relatives of cultivated plants are being collected and grown for careful study of their characters. Crosses between them and their corresponding cultivated species are also made. The important among such crosses under study were :

(*a*) *Sesamum orientale* (2n=26) X *S. prostratum* (2n=32)

Successful hybrids between these two species were raised. The hybrids were intermediate between the parents in respect of many morphological characters but were completely sterile owing to variable pairing of the parental chromosomes at meiosis. Several vegetative buds of the hybrids were subjected to treatment with colchicine with the result that many of the treated buds gave rise to fertile branches with a high degree of pollen fertility and a fairly good-setting. The seeds were carefully collected and weighed, they were bigger and heavier than the seeds of the parent plants. They gave rise to fertile amphidiploids combining the characters of the two parents and having a new chromosome number, *viz.*, 2n=58. With this amphidiploid as the starting point it should be possible to breed drought—and disease-resistant *sesamums* by suitable back-crossing coupled with judicious selection.

(*b*) *Solanum Melongena* (2n=24) X *S. incanum* (2n=24)

Progenies of this cross were grown in summer and also in winter. There are indications that it may be possible to breed varieties suitable for growing in both the seasons. *S. incanum* has bitter fruits, but plants bearing such fruits are easily eliminated in the hybrid progenies by selection.

(*c*) *Lycopersicom esculentum* (2n=24) X *L. pimpinellifolium* (2n=24).

Some of the plants from the crosses were very early and appeared to withstand the hot weather better than the ordinary cultivated varieties. A definite improvment in the size of the fruit was achieved by back-crossing, the latter process has been repeated. Another desirable character which is sought to be introduced in the improved variety is the uniform and almost simultaneous ripening of the fruits in clusters.

(*d*) *Linum usitatissimum* (2n=30) X L. *grandiflorum* (2n=16)

Crosses between the cultivated linseed and *L. grandiflorum*, a horticultural variety which is resistant to rust, were made and a few crossed seeds have been obtained.

V. PHYSIOLOGICAL INVESTIGATIONS.

1. Drought resistance studies with wheat : These studies were in progress with four Indian varieties and three exotic varieties. In a complex experiment, the effect of drought at three different growth phases on pre-treatment and control seed of the seven wheat varieties was studied. One half of the number of experimental boxes received water while the other half received sodium chloride solution. Consistent results were obtained during the three years which showed that (*i*) pre-sowing hardening treatment of seed induced resistance to drought, (*ii*) resistance to drought could be evaluated by growth analysis and yield data, (*iii*) there appeared to be some correlation between phasic development and drought resistance, (*iv*) correlation between drought and alkali-resistance was established, (*v*) plants obtained from pre-treated seed flowered earlier by a few days, (*vi*) 260 Indian and exotic wheat varieties could be classified into different flowering groups which were characterised by definite growth stand.

2. Photoperiodism and vernalization : The photo—and thermo-requirements of the same seven varieties used for the drought-and alkali-resistance experiments were determined. The results show that : (*i*) there is a close correlation between growth and the photo—and thermal-response of wheat, (*ii*) after the completion of the thermo-phrase, the developmental process appears to be essentially photocatalysed, (*iii*) there appears to be a close interdependence between growth and development.

The co-operative experiment with the Agricultural Experimentalist, using vernalized and control seeds of gram I.P. 25 was carried out during 1942-43 and 1943-44. In 1943-44, sowings were done at fortnightly intervals over a longer period than during the previous year *i.e.* from the 23rd of September to the 2nd of December. The first year's observations, *viz.*, that there was a marked earliness in favour of the vernalized plants in the early sowings and that there was a progressive decrease in earliness in the later sowings, was confirmed. A combined light and temperature treatment was given to gram I.P. 25. The variety showed a marked response to light treatment and a poor response to temperature treatments.

With the co-operation of Mr. Boshi Sen of Almora, seeds of 30 exotic varieties of wheat were vernalized and the sowing done at Delhi. A number of varieties gave a marked response to vernalization, that in the case of *T. Vavilovi* being to the extent of over 50 days. Seeds of one hundred and fifty Indian wheats were vernalized and sown on the 5th February, 1944. Although the general stand of the crop was poor both in the treatments and the controls, there was clear response to vernalization

in a number of varieties. In some cases, the treated plants flowered normally while the controls did not flower at all owing to the setting in of the hot weather. Notes taken on the degree of rust attack did not indicate any difference, in this respect, between the vernalized plants and the controls.

VI. MISCELLANEOUS STUDIES.

1. Study of hybrid vigour and the possibility of its exploitation in agriculture.—Brinja 1 : The study of a cross Muktakeshi X Clustered White was in progress. All the three filial generations were grown along with the parents in 1943-44. Both winter and summer crops were grown. In the F_3 generation a gradual decline in hybrid vigour was noticed. Seeds of the hybrid, ' Pusa Purple ' derived from the above mentioned cross were sent for trial to six provinces and to some residents at New Delhi. While the hybrid has been reported to have done uniformly well in New Delhi, its performance in other tracts has been variable.

Maize : In breeding and experiments on hybrid vigour were continued.

2. Seed-setting in Berseem : Experiments conducted at Delhi have definitely shown that bee-pollinations are essential for bringing about seed-setting in Berseem, the presence of more bees in the field at the time of flowering of the crop at Delhi has been correlated with better setting of seed and the absence of the bees at Pusa with shy seed-setting. Controlled experiments with bee hives in the two places have also brought out the important role of these insects in bringing about seed-setting in this crop.

3. Cryptostegia investigations : The situation arising out of the war necessitated investigations on the possibility of developing new sources of rubber in the place of the commercially important *Hevea* rubber. As a first step, assistants of the Section were sent to survey the country to note the occurrence, distribution and abundance of agricultural types of laticiferous plants likely to be source of rubber. As a result of this survey and the analytical work carried out by the Section of the Imperial Agricultural Chemist, *Cryptostegia grandiflora* was ' re-discovered ' as the most likely plant for exploitation in this emergency. As very little was known about the methods of propagation, growth and productive capacity in terms of yield of latex rubber of this plant, collaborate investigations with the Chemical Section and the Rubber Section of the Supply Department were undertaken. As a result of the study carried out by this Section the following results have been obtained : (*i*) Propagation by seed is to be preferred to cuttings. (*ii*) Pre-soaking of seed in water for 24 hours helps in securing larger, quicker and more uniform germination, (*iii*) Raising of nurseries and transplantation of seedlings is ordinarily to be preferred to broadcasting the seed, although the latter method, which is very much less expensive can be adopted in places of good rainfall and moderate temperatures, (*iv*) Seed-rates for nursery and field planting have been worked out and methods of raising nurseries and transplanting have been recommended. (*v*) The plants raised from seed grew slowly in the early seedling stage, but later the growth was fast and luxuriant. The growth was active during the rainy months of July-September and again during March-May. During November-February there was a marked setback in growth and defoliation was observed. (*vi*) Pruning experiments were undertaken to determine the best season and the best type of pruning in order to accelerate growth particularly with regard to ' whip ' branches for utilisation in tapping of latex and for growing plants for mechanical extraction of rubber.

VII. CROP OUTTURNS AND SEED DISTRIBUTION.

During the season 1941-42 a severe frost in the middle of January and an hail-storm in April caused damage to the standing crop. The yields of crops, however were satisfactory. The season 1942-43 was generally favourable for crop growth and the yields were quite satisfactory and greater in most cases compared to those of the previous year. In 1943-44 due to continuous wet winter during the ripening of wheats, both the outturn and quality of grains suffered. There was considerable lodging in some of the wheats and the incidence of rust was heavy. In gram, there was excessive vegetative growth and the yields, due to this and to damage by hail, were considerably reduced. The tobacco crop was practically ruined by hail. The yields of oats were however, satisfactory. Seeds were supplied by this Section and the Botanical Sub-Station, Pusa, to the Agricultural Section for multiplication and also to a large number of officers and private individuals in India and abroad.

VIII. ADVISORY.

As in previous years a large number of enquiries were received from correspondents regarding varieties of crops, methods of breeding, methods of cultivation, economic wild plants, tobacco curing etc., and the information asked for was supplied. A number of plant specimens were identified for various correspondents. A number of scientific articles were also refered for the Imperial Council of Agricultural Research.

IX. PROGRAMME OF WORK FOR 1944-45.

1. The wheat investigations described in this report will be continued.

2. The breeding of disease-resistant linseed, and of both Virginia and *rustica* tobacco will be continued.

3. The cytogenetical studies of *Brassicae* will be continued.

4. The studies bearing on fundumental cytogenetic research including polyploidy and mutation will be continued.

5. The work on the collection, study and utilization of wild relatives of crop plants will be expanded.

6. The physiological studies on drought-resistance and vernalization of Indian crop plants will be continued.

7. The studies on hybrid vigour and seed-setting in berseem will be continued.

8. The collection, registration and maintenance of crop collections will be continued.

REPORT OF THE SUGARCANE EXPERT

(N. L. DUTT)

I. INTRODUCTION.

This report deals with the work on Sugarcane Breeding conducted at the Coimbatore Sugarcane Breeding Station. It also includes the main results of research in the three schemes connected with the Station and financed by the Imperial Council of Agricultural Research. These schemes are (*i*) Sugarcane Sub-Station Karnal, (*ii*) Scheme for research on the Genetics of Sugarcane, Coimbatore, and (*iii*) Scheme for research on the Physiology of Sugarcane, Coimbatore. Of these schemes, the one on the Physiology of Sugarcane is a new scheme sanctioned from April 1942. The Scheme for the Genetics of Sugarcane has been in progress since1934 and terminated in March 1944, but the work on Cyto-Genetics has now been merged into the activities of the Station and is being conducted by the Second Cane Breeding Officer.

II. SUGARCANE BREEDING.

Sugarcane Crosses.—About forty crosses were effected with the object of evolving early ripening and high sucrose seedlings. The more important of these are : (1) Co. 281 × S.G. 63/32, (2) Co. 281 × Co. 301, (3) Co. 349 × Co. 313, (4) Co. 349 × Co. 299, (5) Co. 508 × S.G. 63/32, (6) Co. 508 × G. 2899, (7) P. 4626 × Co. 453, (8) P. 3247 × Co. 508 and (9) Co. 440 P.O.J. 2878. From among the above parent canes, S.G. 63/32 imparts to its progeny not only the high sucrose quality but also the capacity for maintaining the high purity from October to January—a character of great value in commercial cultivation. The canes P. 3247, P. 4626 and Co. 440 are valuable additions to the list of parents for evolving early ripening seedlings. As regards Co. 281 the fact that even though it possesses plenty of pollen it is essentially self sterile was very helpful in the utilization of Co. 281 as a female parent in new combinations. For obtaining general purpose seedling canes which are vigorous in growth and give high yield of cane at harvest though somewhat moderate in sucrose percentage (but contributing more sugar per acre ultimately) a few outstanding parents are now available. These are P. 2607, Co. 453 and Uba Marrot. The cross effected for obtaining general purpose canes were (*i*) P. 2607 × Co. 453, (*ii*) Co. 421 × Co. 419, (*iii*) Co. 419 × Co. 285, (*iv*) P.O. J. 2878 × co. 312 (*v*) P.O.J. 2878 × B3412, (*vi*) P.O.J. 2878 × Co. 301 (*vii*) Co. 443 × Co. 281, (*viii*) Co. 213 × Uba Marrot and (*ix*) P.O.J. 213 × Uba Marrot. The cross Co. 349 × Uba Marrot was also effected but the majority of the seedlings showed pronounced pith formation and had to be rejected. Besides the above, over two hundred other crosses were effected. These were of an experimental nature to observe the type of seedlings obtained and to assess the value of new combinations. A population of 100 seedlings in each cross was planted in the Second Ground Nursery for these studies. The Station possesses very few seedlings of Fiji B (Badila) parentage. Badila does not flower normally at Coimbatore but does so fairly regulary in the West Coast. Advantage was taken of this and pollen of Co. 419, Co. 285, and Co. 290 was transported (by the vacuum flask method developed at the Station, vide Saradhy, V., 1939, " Current Science ", Vol. 8, No. 12) from Coimbatore to Pattambi and Mangalore and the crosses effected.

Sorghum crosses.—The following crosses have yielded quite promising seedlings; (1) Co. 349 × (vallai × Sorghum Durra, Stapf), (2) P. O. J. 2878 × (Vallai × Sorghum Durra, Stapf). The utilisation of the parent S.C. 851 has been kept in abeyance till more is known about the performance of the seedlings already obtained from it.

Bamboo Crosses.—Three Bamboo seedlings, viz., Co. 562, Co.563 and Co. 564 have already been distributed for trail at the Provincial Stations (in February 1942) and a fourth, viz. Co. 606 was similarly distributed in February 1943. The performance of these will be watched with a view to adjusting the Bamboo hybridization on the basis of the reports on these seedlings. The utilization of the bamboo itself (direct cross) is attended with certain difficulties, which in themselves are by no means insurmountable. These are, the irregular and indefinite nature of Bamboo flowering, secondly the difficulty of synchronising bamboo flowering with that of sugarcane and thirdly the rather rare germination of bamboo pollen on the stigmas of sugarcane. Because of the above but chiefly because of the fact that the direct bamboo blood introduces impurities in the juice it is proposed to utilise in the future corssing work such of the desirable Sugarcane × Bamboo seedlings that are already available and if they prove unsatisfactory, the direct corssing of bamboo will again be resorted to secure, if possible, better F_1 seedlings. During the 1942-43, and 1943-44 crossing seasons the bamboo hybrids B.h.V., B.h. IX and B.h. IX-57 were further utilised in about ten crosses with certain high sucrose canes.

Other Intergeneric crosses .—Another suitable parent for introducing profuse tillering was secured in the fertile hybrid which arose in the hybridization between M.2819 (S. officinarum × Narenga porphyrocoma) and Co. 205 (S. officinarum × S. spontaneum).

Crosses for sending 'fluff' .—About half-a-dozen different crosses were effected, as desired, for sending the ' fluff ' to certain experiment Stations. The crosses are :— Co. 421 × Co. 312, Co. 421 × Co. 313, Co. 421 × Co. 331, Co. 312 × Co. 313, Co. 312 × Co. 285, P.O.J. 2725 × Co. 281 and P.O.J. 2725 × Co. 301.

Crosses for evolving chewing canes.—The production of chewing types has been somewhat of a problem. Usually the ones likely to find favour are such as are of pure noble parentage (i.e.) *Saccharum officinarum*. The draw backs in such canes are that they are unable to withstand drought and frost and their yield is low. To remove the above defects about half-a-dozen combinations have now been tried and certain of the seedlings are somewhat promising. These are not in the test plots.

III. INVESTIGATIONS.

*Cyto-genetical Studies**.—Chromosome numbers of ten more forms of Saccharum spontaneum were determined and a scrutiny of the numbers with reference to the places of collection reveals that forms with low numbers (i.e.) n = 27, are found in North or North West part of India. A steady increase in chromosome numbers occurs in forms collected in tracts in a South Easterly direction. The Lahore and Dehra Dun types have n = 27 while the Bihar forms have n = 28, 30, 30 + 1, 32 and 36. The Assam and Burma forms have n=40 whereas East Indies types have n=54 and 56.

* The Scheme was financed by the Imperial Council of Agricultural Research and the work is now continued by Dr. N. Parthasarathy, appointed as Second Cane Breeding Officer on 6th May 1943.

Chromosome counts in the seedlings of successive backcrosses of sugarcane with wild parent (Sclerostachya) show a progressive reduction in the numbers, initiating favourable conditions for the pairing and exchange of characters between sugarcane and Sclerostachya chromosomes. Back corssing with wild parent thus envisages the possibility of the evolution of wild parents with desirable economic characters as vigour, habit, disease resistance etc., with the chief characteristic of sugarcane, (i.e.) sugar contents. These types, with greater expectation of obtaining commercial types could be directly corssed with selected Co. canes.

Cytological studies on the megasporogenesis of Co. 421 to investigate the origin of the production of gametes with unexpected number of chromosomes indicated irregularities both in the first and second divisions of meiosis while the corresponding divisions in the macrospore was quite regular. The irregularities consisted mainly in the lagging of some chromosomes without reaching the poles resulting in the non-inclusion of some chromosomes in the nuclei. The possibility of the formation of gametes with chromosome numbers lesser than the haploid number is thus indicated.

*Physiological Studies.**—Photoperiodism experiments for inducing flowering in non-flowering varieties and for hastening or delaying the reproductive phase in certain sugarcanes, used as parents, have yielded very interesting results. Some varieties as *Sacharum* spontaneum, Burma, which do not flower at Coimbatore, have been induced to flower by considerably reducing the daily photo period about eight weeks prior to commencement of the flowering season. Similarly some other varieties like Co.421, P.O.J. 2725 and *Saccharum spontaneum* (Tabongo) which flower very early in the season have been made to flower late by a period of about two months, by altering the day length at suitable stages in the life of the plant.

Valuable information has been obtained on the effects of manurial and irrigation treatments on inducing flowering. By withholding the normal manurial treatments and increasing the water supply it has been made possible to induce flowering in certain recalcitrant varieties such as Red Mauritius, Baroukha 13A and Sewari, which seldom flower at Coimbatore ; and considerably hasten the time of flowering in others like Vellai, P. 4626 and Co. 468. Detailed pot culture experiments have also confirmed the above results. It may now be definitely stated that light manuring at the time of planting and plenty of water supply throughout the growing period are conditions conducive to flowering in sugarcane. The application of heavy doses of manure (Groundnut cake and Ammonium sulphate) particularly at the later stages of growth, with normal rate of water supply provides us with conditions which inhibit or considerably delay flowering in sugarcane ; times of flowering can to a great extent, be controlled by adjusting these two factors viz., manuring and irrigation. Chemical treatment with Zinc Sulphate has been successfully used to induce flowering in Red Mauritius, a variety which is not known to flower at Coimbatore.

As regards the chemical composition of flowering and non-flowering varieties, attention has been mainly devoted to C/N ratio. The chemical analyses are in progress and the data will be reported in the next Report.

Pollen storage and transport.—Attempts to transport pollen by post and rail from Karnal (a distance of about 1,700 miles) during the year have not been successful. The problem of pollen storage and transport is assuming importance in Sugarcane

* This Scheme is financed by the Imperial Council of Agricultural Research and work is being conducetd by the Plant Physiologist, Mr. N. D. Yusuf.

Breeding. Kept at Zero to eight degrees Centigrade sugarcane pollen has been found to maintain its capacity for germination up to more than a month. Recently, it is mentioned that pollen in grasses may not maintain its capacity for fertilisation for more than a day though the capacity of germination is unimpaired. This is because in grasses the generative nucleus divides into two sperms, before germination and these sperms die in about a day. Preliminary investigations reveal however that *Saccharum spontaneum* pollen maintained its fertilising capacity up to four days. Detailed trials on this problem are planned for the coming year.

Seed germination studies.—Viability counts of sugarcane seed gave (1) a greater percentage of germination in seeds collected from the lower half of the arrow than the upper half, (2) seeds from first formed arrows were more viable than those from the late arrows. Investigatinns of the crosses for the rapid deterioration in the viability of cane seed with age and its probable relationship with changes in chemical composition are in progress.

Chemical Studies.—Further observations on the growth of the cane and quality of the juice showed (1) greater amount of tillering in garden lands (2) greater number of arrowing canes in wet lands and (3) increased weight in canes grown in the garden lands.

Certain preliminary observations on the fibre content and juice extraction (in a three roller crusher) showed that high fibre content in certain Co. canes was not always associated with low extraction indicating thereby that it is the quality of the fibre and not merely the quantity that determines juice extraction.

IV. SUGARCANE SUB-STATION, KARNAL.**

Since April 1942 a Live Herbarium of the Indigenous canes of North India as also the wild species of Saccharum and allied genera is being maintained at Karnal. A collection of the commercial canes cultivated in the North Indian tracts is also being maintained at Karnal with a view to this Sub-Station serving as a clearing house for information regarding the correct identification of these varieties.

Useful results have already been obtained by locating the Herbarium at Karnal Certain useful forms of S. spontaneum which had not till now flowered at Coimbatore and were thus unavailable for breeding, have flowered at Karnal. With the advances in the physiological methods to adjust the times of flowering and perfection of the methods of pollen storage and transport further advance in breeding is visualised.

V. RECEIPT AND DESPATCH OF CANES.

(a) *Receipt of canes.*

Exchange of breeding material with the other leading experimental Stations of the world has been an important activity of this Station. Owing to war conditions this activity was at a standstill during the years under report.

** Financed by the Imperial Council of Agricultural Research.

(b) *Distribution.*

As canes.—Nearly 200 parcels containing the new Co. canes as well as other canes specially desired were sent out to various places in India.

Seven Co. seedlings were handed over to the Chinese Agricultural Mission for trial in China. Six Co. seedlings and one Barbados variety (B. 6308) were despatched to Persia by post parcel. Canes were also supplied to Officer in Charge, British Mission, Lhasa.

As fluff.—Hybrid seeds of desired combinations were sent to the Economic Botanist, Shahjahanpur (U.P.), Sugarcane Specialist, Risalewala (Punjab), the Director of the Botanical Section, Ministry of Agriculture, Egypt, and Director, South African Sugar Association Experiment Station, Mount Edgecombe, Natal.

VI. NEW COIMBATORE SEEDLINGS.

The parentages and general characteristics of the new Co. canes are given below :—

(a) *Distributed in February 1942.*

Co. 470—P.O.J. 2878 × Co. 331
Co. 471—P.O.J. 2878 × Co. 508
Co. 472—P.O.J. 2878 × Co. 313
Co. 473—P.O.J. 2878 × Co. 455
Co. 474—P.O.J. 2878 × Co. 419
Co. 475—(Co. 421 × Co. 440) × Co. 419
Co. 476—Co. 285 × Co. 440
Co. 476 is the last cane of the Co. 400 series
Co. 562—Co. 213 × Bh. IX
Co. 563—, Co. 564— } Co. 349 × Bh. IX
Co. 565—, Co. 566— } P.O.J. 2878 × S.G. 63/32 (i.e., P.O.J. 2725 × Imperata sp.)
Co. 566 is the last cane of the Co. 500 series

(b) *Distributed in Feburary 1943.*

It has been felt for sometime that there is not much justification for the Co. canes to be in two separate series, viz., the 400 series and Co. 500 series. The original idea of the two series was to represent the two classes of canes from Coimbatore, i.e., the tropical and the sub-tropical types respectively. As the production of both the types has tended to approach each other in technique, it has now been decided to include both the types in one continuous series, and accordingly the new Co. canes in the current season start from Co. 601. They are eleven in number and are enumerated below with their parentages and general characteristics.

Co. 601—Co. 417 × Co. 413. A medium cane of the type of Co. 413. Fair sucrose and yield. Sparse flowerer.

Co. 602—Co. 421 × Poovan. A relatively early ripener. Canes of Co. 421 type and thickness.

Co. 603—(Co. 421 × Co. 440) × Co. 419. A thick cane of early maturity and good sucrose. Yield and certain other characters somewhat like those of Co. 349. Of possible untility as a chewing cane.

Co. 604—Co. 464 × Co. 419. A tallish cane with fair yield. More or less Co. 421 type but with better sucrose.

Co. 605—Co. 453 G.C. (Likely father Co. 412). A very vigourous grower and fairly heavy yielder. A Co. 453 type of cane.

Co. 606—Co. 349 × Bh. IX. Contains a trace of Bamboo blood. Is of the same parentage as Co. 563 and Co. 564, but is better in sucrose than both.

Co. 607—Co. 421 × Co. 331. A medium cane of fairly good habits and yield. Scores over both Co. 421 and Co. 331 in sucrose.

Co. 608—Co. 213 × (P.O.J. 2725 × Imperata sp.). A heavy yielder. Medium in thickness. Sparse flowering and moderate sucrose.

Co. 609—, Co. 610— } Co. 385 × (P.O.J. 2725 × Imperata sp.). Both of these are thin medium canes which are likely to yield better than Co. 385. They are early maturing with high sucrose, particularly Co. 610.

Co. 611—Co. 385 × Co. 312. A thin medium cane which combines in itself the good qualities of Co. 385 as well as Co. 312.

(c) *Distributed in February 1944.*

The 1944 batch of Co. canes consists of eleven varieties which are enumerated below with their parentages and general characteristics. In selecting these canes due regard has been paid to the requirements of the various cane tracts in India. Two or three of these canes are such as are rich in sucrose and fairly early in maturity. The selections also include "general purpose" canes of the thickish types for the tropics and thin-medium types for the sub-tropical belt.

Co. 612—Co. 417 × P.O.J. 2878. A late ripener but very good yielder. A Co. 419 class of cane.

Co. 613—Co. 419 × Co. 285—A vigorous grower, selected because of good parentage and fairly heavy yield. Canes medium in thickness.

Co. 614—Fiji B (Badila) G. C. (Likely father Co. 419). Belongs to the Co. 419 class but definitely sparse in flowering.

Co. 615—Co. 419 × B. 3412. This also belongs to the Co. 419 class but is somewhat sparser in flowering.

Co. 616—Co. 440 × P.O.J. 2727. A moderate yielder but rich and early in sucrose A Co. 349 class of cane.

Co. 617—P.O.J. 2878 × Co. 285. A cane of Co. 285 class but better in sucrose and of fairly erect habits.

Co. 618—P.O.J. 2878 × Co. 285. Canes thin to medium. A good grower and a fairly heavy yielder.

Co. 619—P.O.J. 2878 × Co. 312. Belongs to the Co. 312 class but with slightly better habits. Yield good, but sugar about the same as Co. 312. Very sparse flowerer.

Co. 620—P.O.J. 2878 × Co. 313. A Co. 313 class of cane, fairly early in ripening with satisfactory sucrose. Leaves strip easily. A sparse flowerer.

Co. 621—Co. 421 × Co. 393. Canes thin to medium. A moderate yielder with satisfactory sucrose. Fairly early in maturity.

Co. 622—Co. 421 × Co. 331. A fairly vigorous grower with erect habits. A heavy yielder combining in itself the good qualities of both the parents and with better sugar.

VII. PROGRAMME OF WORK FOR 1944-45.

Breeding with particular emphasis on specialised characters as 'early' and 'late' maturity, disease resistance, non-pithy character of the stem and chewing quality.

Cytogenetical studies with reference to the utilisation of wild parents in economic breeding and the inheritance of economic characters.

Physiological studies on the chemical composition of flowering and non-flowering cane varieties and the intiation of reproductive phase in non-flowering canes by photoperiod treatments and chemicals.

Pollen storage and the determination of the fertilising capacity of such pollen, based on hybridisation experiments.

The relationship of anatomical characters to disease, drought and frost resistance and their inheritance in cane hybrids.

REPORT OF THE SECTION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY.

(Dr. S. V. Dasai, II Agricultural Chemist I/C)

I.—WAR WORK.

1. *Rubber.*—Due to the exigency of war, special work on research for rubber in latex bearing plants was undertaken. 82 samples of latex from different latex bearing plants were analysed. Ultimately the plant *Cryptostegia grandiflora* was found to be the most promising. A method of tapping the plant by attaching multiple receptacles to the cut ends was evolved which gave appreciable collection of latex having considerable amount of rubber hydrocarbon. Tapping of the plants once in three days gave maximum economic yield of rubber. The method of coagulating the latex by dilution with water in the ratio 1 : 5 was found to be satisfactory.

It was also observed that the latex had a critical coagulating pH at which the maximum coagulation took place. The formation of rubber in the plant at different stages of growth from germination onward was under study.

The latex of Lobelia excelsa was also examined. It yielded a rubber of poor quality and the experiments to improve the quality of rubber were not successful.

2. *Production of Butyl alcohol and acetone by microbiological fermentation.*—A strain of organism was isolated from maize roots which was capable of fermenting maize mash to butyl alcohol and acetone. This organism also fermented molasses of sufficient proteins, in the form of oilcakes, were added to give proper carbohydrate protein ratio in the mash. The production of butanol and acetone was found to be 25% and 12·5% of the carbohydrate respectively. Besides this organism, several other organisms were isolated from other sources for examining their power of producing butanol. The efficiency of the organisms to produce butanol was highly variable and depended on the history of their cultivation on different media. The efficiency was found to be directly related to the sporulating tendency of these cultures. Experiments were carried out to restore the efficiency of cultures which had deteriorated and it was observed that repeated transfers of heated spores at short intervals in maize broth were helpful. Various cereals as well as carbohydrates were used as sources of energy for the organism and the fermentation was equally good in all the cases.

3. *Determination of moisture in dried fruits.*—It was found that Xylene distillation method was unsuited for the purpose of estimating moisture in dried fruits which contained a large percentage of invert sugars. While the drying in vacuum at a pressure of 10 mm. of Mercury at 70°C for six hours was the most accurate method, the Toluene distillation method was quicker and very nearly accurate if the temperature of the boiling liquid was not allowed to rise above 112—115°C.

4. *Material for water and fire proof paints.*—Alternative sources of protein in place of casein were examined for Camouflage Department as to their suitability for use in preparation of water and fire proof paints. Proteins isolated from various oilcakes were found to be suitable and practical way for their extraction was worked out.

5. *Utilization of ammonium nitrate and its mixtures with T. N. T. from ammunition stores as a fertilizer and the problem of their storage.*—A consignment of ammonium nitrate and its mixtures with 1%, 2% and 3% T.N.T. was sent by the Master General of Ordnance. Various materials were mixed with ammonium nitrate to prevent the formation of hard cake. With some materials like soap-stone, calcite, yellow ochre,

china clay and fuller's earth the formation of hard lumps was retarded and some materials like Delhi soil apatite and bonemeal augmented the formation of hard lumps. Experiments to find out the manurial value of the fertilizer in Delhi and Karnal soils were planned. Small plot experiments were laid out in the Chemical Section to find the effect of the T.N.T. mixtures.

6. *Air foam compounds as fire extinguisher.*—In the course of studying the problem on the isolation of the alkaloidal principle from *Solanum xanthocarpum* it was observed that the colloidal solution of the base gave copious and stable foam. This suggested its use for preparing a compound as fire extinguisher. The acid extract when neutralized gave standard amount of foam in 5% solution. By using unripe fruits and alcohol for extraction of the base it was possible to obtain a concentrated solution. When 5% soapnut powder was added to stabilize the base the compound gave standard amount of foam in 1% solution.

7. *Dehydration of meat.*—Some experiments on dehydration of meat cooked under pressure were carried out at the instance of the Chief Technical Adviser to the Food Department. It was found that precooking at 23 lbs. pres sure for 2 hours resulted in a well cooked product with a loss in weight of about 50% due to separation of water and fat. The fat content of the finished product ranged from 10 to 12% in case of goats' meat and mutton and had an agreeable flavour.

II.—RESEARCH AND INVESTIGATIONS.

1.—Soils.

1. *Soil map of India.*—The soil maps of India, one in colour and the other in black and white, were published to show the major soil divisions and their distribution in India based on colour classification. Further charts and maps showing the distribution of nitrogen and phosphorous in various types of soils were also prepared.

2. *Comparative study of the soils of India.*—Number of charts and maps were prepared to bring out the relationship of the types of soils and their distribution with climatic and other physical factors. Charts and maps were also prepared for showing the distribution of important chemical constituents and their ratios in different types of soils. Eleven papers on the subject were sent up for publication.

3. *A new system of soil notation for comparative study of soil characteristics.*—The present methods of expressing the different soil characteristics are far from satisfactory as they do not often lend themselves to easy adoption in practice. Thus the orthodox method of giving the values of mechanical analyses to two places of decimal is cumbersome while grouping soils as sand, loam, clay loam, sandy loam, etc., makes only a vague classification. A system of presenting the data of aggregate or mechanical analysis that may commend itself to field workers would be to round off the percentages of sand, silt and clay for each soil horizon to their nearest tens, and after eliminating the end zero combine them to give a three figure number, which would denote the particular horizon. Thus at a glance it is possible to grasp the approximate textural composition of the soil and compare it with others without confusion. A number like 721 would, for instance, denote that the soil has 65 to 74·9 per cent. sand, 15 to 24·9 per cent. silt and 5 to 14·9 per cent clay. The advantages of this representation are obvious.

This system of representation is elastic and any other data of importance could be associated with the index by appropriate number or alphabet. Thus the influence of climate can be incorporated with the soil index showing the textural composition. For associating the Meyer's factor it is modified by rounding to the nearest ten and eliminating the last zero so that brevity, so essential in such numeric representation, could be maintained.

In addition to the association of Meyer's factor with the index, the colour classification of the soils can also be associated likewise. Without attaching much importance to fine variations, the soil colours may be classified into the following groups, of which the initial letter or letters may usefully be associated with the numerical index : (1) Red (R) (2) Black (B), (3) Grey (G), (4) Brown (Br.) and (5) Yellow (Y).

The following table gives the results of analysis of a few typical soils from various research stations together with an expression, in the last column, of these results by the above nomenclature. It may be seen that the comparative evaluation of soils is made simple by the adoption of the proposed system.

Locality.	Aggregate Analysis			Meyer's factor	Soil Index.
	Sand	Silt	Clay		
Black soils					
Akola	39·6	40·4	20·0	143·4	B. 442·14
Labhandi	34·6	48·6	16·8	237·2	B. 352·24
Hagari	39·6	32·5	27·9	91·3	B. 433·09
Padegaon	35·2	38·4	26·4	132·3	B. 443·13
Red soils					
Ranchi	60·2	31·7	8·1	318·1	R. 631·32
Taliparamba	52·1	31·3	16·6	753·9	R. 532·75
Coimbatore	67·2	20·0	12·8	162·0	R. 721·67
Sirsi	72·7	21·8	5·5	666·5	R. 721·67
Grey soils					
Delhi	72·9	19·6	7·5	123·7	G. 721·12
Kangra	59·5	34·8	5·7	676·0	G. 631·68
Shahjahanpur	81·6	15·6	2·8	205·3	G. 820·21
Karimganj	40·6	51·6	7·8	132·8	G. 451·13
Chinsura	18·7	62·8	18·5	426·6	G. 202·43
Samalkot	65·9	23·4	10·7	223·0	G. 721·22
Tabiji	90·2	7·4	2·4	110·2	G. 910·11

It is possible on the same basis, to work out chemical indices for soils. Thus soil containing 42 mgm. of N, 54 mgm. of P_2O_5 and 200 mgm. of K_2O could be represented by $N_4P_5K_{20}$ which would be a very suitable index for comparative purposes Similarly, values for soil reaction and exchangeable bases can also be suitably abbreviated and added to this index wherever these values are known to influence crop yields.

The system of notation suggested here can be improved upon or modified to suit the individual problems of the soil surveyor. An agreed notation on these lines would greatly help in comparative soil studies and ultimately in all soil crop relationships.

4. *Fixation of phosphates by different soils.*—42 surface soils from different parts of India representing various soil types were studied for phosphate fixation purpose. In general the soils of Indo-Gangetic plain from Assam to the Punjab had low fixing power. The soils of gneissic area including coastal alluvium as also from southern India including coastal parts had medium fixing power and the black cotton soils of Central India including C. P. had high fixing power for phosphate. The effects of pH

clay content, total exchange capacity, exchangeable bases, SIO_2/R_2O_3 ratio and other soils characteristics on the phosphate fixing capacity were worked out. The phosphate fixation was inversely related to SIO_2/R_2O_3 ratio and directly related to pH, clay contents, total exchangeable capacity and exchangeable bases. The black soils had the highest fixing power while brown soils were of low fixing capacity. The red, pink and grey soils were intermediate in this respect.

5. *Defective Nitrification.*—Experiments were conducted for nitrification at different levels of moisture contents, namely, 1/3, 1/2 and 2/3 saturation capacity of the soils of defective nitrification belt, and it was found that the optimum moisture conditions for nitrification in most of these soils was 1/2 the saturation capacity and not 1/3 the saturation capacity as is usually the case in most soils. This appears to be the explanation for the cause of the observed defective nitrification in some of the soils.

6. *Soil Survey of Delhi Farm area.*—The soil survey of the whole of the cultivated and reserved areas of the Delhi farm was carried out. At every 330 ft. distance, samples of soil to a depth of 3 ft. were taken and analysed for aggregate structure footwise. The soil maps of Delhi farm area were prepared showing the major classes of soil to a depth of three feet in horizontal layers of one foot. As a result of these studies it was found that the major portion of the area consisted of sandy loam. Patches of sandy soil and a few patches of loam and clay loam were located here and there both in the reserved area and in the main block. Clay loam was found in a consolidated block towards the Bund while loamy soil was found near about this area. On the basis of values for the first foot, the total area was classified as follows :—

10·6 per cent. sandy,
77·7 per cent sandy loam,
8·9 per cent. loam,
2·8 clay loam.

Maps were also prepared using the new method of notation classification.

7. *The spectroscopic study of soil colours.*—A new line of investigation was the study of soil colour with the aid of spectroscope by measuring the reflection coefficients for different wave lengths. Generally the reflection was the largest in the region of long wave lengths. Judging from comparative studies with iron oxides and iron silicates leached to varying degrees, the colour of soil appeared to be determined principally by the nature of iron compounds and the degree of their leaching and hydration. The reflection spectra of soils can be divided into two main divisions, *viz*, the spectra in the violet region and in the red region. The results so far obtained indicated the possibility of differentiating the geological and climatic effects on soil formation.

8. *Distribution of boron in Indian soils.*—Large number of samples obtained from all over India were examined for their boron content by spectrometric method. The data of boron contents were also correlated with geological formations from which the soils were derived and boron contents were found to be affected by irrigation and manurial practices. Manuring with oilcakes and artificials was found to increase the total boron content in surface soil and increase availability in calcareous soils like that of Pusa.

9. *Minor elements and formation of good and bad patches in the field.*—Good and bad patches of considerable magnitude were observed to occur in some experimental plots of wheat and barely. The analysis of leaves from these bad patches showed a deficiency of manganese and boron in their ash.

10. *The alkaline patches in Pusa soil.*—Samples of soil from alkaline patches as well as from the good soils close by were taken from Gonhri and Botanical Pentangular area and examined for their salt contents. The soluble salts in alkaline patches were mostly sodium bicarbonates. In Gonhri field 71% of the total salt contents were sodium salts against 25% in the normal soil. The corresponding figures for the botanical area were 67% and 23%. Circular development of alkaline patches indicated that the accumulation of the salts at particular spot may be due to bad drainage at a particular point and the formation of sodium complexes at the spot rendered neighbouring soil impervious and ultimately alkaline. In years of normal or heavy rainfall the effect of alkaline patches was not very marked while it appeared in years of low rainfall. For this reason kharif crops were less affected than the rabi crops.

If CO_2 was passed through the suspension of soil from alkaline patches a lowering of the pH and increase in the soluble salts of sodium and potassium resulted with corresponding decrease of these elements in the soil complex. This was followed by flocculation of the soil particles, indicating that the sodium and potassium in the clay complex were replaced by calcium and magnesium by this treatment. It was further observed that alkalinity was not necessarily followed by high pH, unless the soil contained clacium carbonate.

11. *Usar soil studies at Karnal.*—The practice of mulching with farm wastes was found useful to control and retard the rise of salt from the subsoil to prevent usar formation.

12. *The after effects of maize crop on wheat.*—Pot culture experiments were carried out to find out the reasons for the depressing effect of maize on wheat. These experiments showed that if the soil in which maize was grown was leached out thrice with water soon after the harvest of maize, the ill effect on the following crop of wheat was not seen. Treatments with $CaCO_3$ and leaching out ten days before the sowing of wheat were also good. The treatments with ferric hydroxide and manganese dioxide were not so effective. Treatment with vecticol, tannic acid or exposure to sunshine in thin layers were only slightly better than the control which did not receive any particular treamtent. Having avoided the ill effects due to stubble decomposition, these experiments supported the theory of the formation and excretion of soluble toxins by the maize plants during growth, and their diffusion in the soil. The toxins had a detrimental effect on nitrifying organisms and therefore interfered with adequate production of nitrates during early stage of the growth of wheat.

13. *The relative values of nitrogen in farmyard manure, compost, oilcake and sulphate of ammonia.*—This problem was suggested by Sir John Russell for investigation at the Institute and therefore with the inauguration of the Development Scheme a detailed scheme was drawn up in collaboration with the Imperial Agriculturist and Agricultural Experimentalist. 1,080 soil samples were collected from the area which was selected for the experiments and the detailed study of variations in N, P and K content in these plots was made.

In this connection rapid methods of estimating N, P and K were developed to permit the handling of large number of samples as well as to give data for allowing small differences to be significant. Short notes on the methods of estimating these constituents were published.

Preparatory to taking up the main investigation, an intensive study of the sampling technique and the errors in sampling together with personal errors in various estimations was undertaken.

In all the 72 plots, laid out for the experiment, the distribution of N and P_2O_5 was found to decrease with depth while that of K^2O was same in all the three layers. When examined, blockwise, there being 6 plots in each block, the distribution of nitrogen was almost uniform and no significant differences could be found between the blocks. The distribution of P_2O_5 was not so uniform. The P_2O_5 content of block No. 6 was more than that in other blocks. Blocks 3 and 5 contained more P_2O_5 than 2 and 4, the differences, however, were not significant. Thus with a slight variation, the P^2O_5 was more or less equally distributed throughout the blocks. K_2O contents of various bloks were uniform and no significant difference between the blocks was observed.

The maximum amount of nitrogen was recovered from plots treated with complete mineral, next came plots receiving activated sludge then those receiving organic manures along with the inorganic fertilizers, followed by the plots receiving rape cake. In the case of the crops from F. Y. M. and compost treated plots recovery of nitrogen was the lowest. This showed that better response was obtained when the fertilizers were applied in inorganic forms or when organic manures had been supplemented with inorganic nitrogen. The response to complete organic manures was much lower than those given by the inorganic fertilizers in Delhi soil.

14. *Rapid methods of analysis.*—The following methods of analysis were devised for experimentation—

(*a*) Estimation of N

(*b*) Estimation of P

(*c*) Modifications in the methods of aggregate analysis

(1) Beaker-Basin method

(2) Turbidity method

(3) Coarse/fine ratio

(*d*) Micro methods of estimating Cu, Mn, Zn, and B. These were standardised

(*e*) Investigation on Corbet's method of estimating Nitrate, Hyponitrate, and Hydrosylamine

(*f*) Fusel oil as a substitute for amyl alcohol in milk fat determination by Gerber's method.

A rapid method of estimating the total solids in water and water extract was developed The method was based on the ratio of anions to cations in salts usually present in such extracts. It was found that total solids were 1·5 times the sum of acid radicals. The acid radicals can be easily and accurately determined and therefore the total solids can then be easily calculated from these results.

15. *Anaerobic fermentation.*—The decomposition of F. Y. M. under anaerobic condition was studied. Laboratory experiments indicated the possibility of its use on large scale. But it was first considered necessary to understand any difficulty that might be encountered while experimenting on a semi-large scale using F.Y.M. from two or three cattle. A tank was thus erected and used for fermenting F.Y.M. under anaerobic conditions. The main findings were—

1. The air temperature had much to do with the rapidity of the fermentation.

2. The rapidity of decomposition that was observed in the laboratory could not be reproduced under semi-large scale conditions because the materials added were coarse and not finely subdivided as was the case under laboratory conditions. Further, during the addition of fresh material small amount of air got into the digestion tank which lowered the efficiency of anaerobic fermentation, as measured by the production of fuel gas.

3. Water had to be added to make the fresh F. Y. M. sufficiently semi-fluid to be in a condition for putting in the tank. Addition of one bucketful of water to every bucketful of cowdung and litter was found necessary.

4. The digested material dried easily by exposing in the sun for a day or two giving a flaky material which crumbled up easily and gave no offensive smell.

The fermented material did not breed flies and the maggots put in it died. The manure prepared in this way was compared on the field scale experiments with farmyard manure, dried dung, activated sludge, etc. It was found that anaerobically fermented manure was better than the manures prepred by other methods.

The nitrogen content of the fermented material was 1·71 per cent. The nitrification experiments showed that the product was superior to F. Y. M. or compost and nitrified easily. The experiments to compare the value of differently prepared F. Y. M. showed that anaerobically fermented manure was superior to all other types prepared in open pit, covered or when freshly sun-dried.

16. *Relation between microbiological status and the soil fertility.*—These studies were undertaken with a view to elucidate the relation of microbiological activity to soil fertility and plant growth. Soil samples were collected periodically from the plots of the permanent manurial series (old), at Pusa, where definite fertility levels were established. Numbers and activities of the soil microflora taking part in ammonification, nitrification, cellulose decomposition, nitrogen fixation, denitrification and carbon dioxide evolution were determined in each set of soil samples. It was observed that the bacterial population and ammonifying, nitrifying and carbon dioxide evolving powers, were higher in the soil samples from plots receiving green manure plus super, farmyard manure, or complete artificial fertilizers (N+P+K) which were of high fertility than the corresponding values in the soil samples from the green manure treated plot, potassium sulphate treated plot and the unmanured plot which were of low fertility.

A fair degree of correlation was obtained between the soil microbiological activity as determined by the evolution of carbon dioxide from the soil and the crop yields from plots at Delhi, receiving nitrogen in different forms, and those from plots of the permanent manurial series at Pusa.

Irrespective of the time of taking the sample, definite levels of microbial activity were established in the different plots at Pusa and the order of activity was also the order of crop yields. The addition of deficient element or elements in the form of fertilizer for proper microbial activity increased the microbiological activity which enhanced the formation of available plant nutrients in the soil resulting in the increase of crop yields. From this the possibility of finding the manurial needs of a soil by its response in carbon dioxide production was envisaged.

17. *Evolution of a method to assess soil fertility and to indicate the manurial needs.*—The microbiological method of measuring carbon dioxide evolution with various treatments of N, P and K in available form was evolved in this laboratory and it gave information which helped to interpret the inherent soil fertility and indicated the manurial requirements. It further indicated whether nitrogen, should be applied in the form of organic manure or in the form of inorganic fertilizers and observation on the farm showed the usefulness of the method. This method indicated that the soil at Delhi Farm required nitrogen in an inorganic form. In comparative experiments on the farm, the application of farmyard manure decreased the yield below that given by the unmanured plot. In another experiment the application of artificials gave pronounced increase in yield over that, given by the various forms of bulky organic manures such as F. Y. M. and compost, and when half the nitrogen was supplied in the form of artificials and half in the form of organics the yeilds were in between the two limits. This definitely pointed to the deficiency of available nitrogen in Delhi soil. A wide publicity for the method and its trial wherever manurial experiments are being conducted would be a great help in judging the practical utility of the method.

18. *Crop composition under various fertilizer treatments and the requirement of soil.*—Analysis of the grains showed that the crop of the phosphate treated plot contained more nitrogen on percentage basis as well as on the basis of total absorption by the produce, than the crops of the control or of the plot treated with potassium. On the other hand the absoprtion of P was not influenced by the addition of nitrogen to soil. This showed that the limiting factor of soil fertility was the amount of available P in Pusa soils. The result of the investigations so far carried out gave ample evidence to the correctness of the theory behind the new method developed for determining the manurial needs of a soil, namely, that by supplying the mineral deficient in the soil for proper microbial activity, the microbilogocal activity can be enhanced and other nutrients in addition to the mineral supplied could be brought into the available form for the crops.

19. *Microbiological activity and formation of patches of poor growth in Delhi soil.*—Soil samples were taken from the affected patches as well as from the adjacent places from the same field. Microbiological and chemical examination of the samples revealed that both were identical in their available nutrients and microbiological activity. It was then thought that removal of the soil and mixing it up for sampling may be responsible for this identical behaviour and, therefore, arrangements were made to measure the evolution of carbon dioxide from the soil, *in situ*. These studies showed that the evolution of carbon dioxide from the bad patches was much less than that from the good patches. This denoted that the local conditions in the plots, rather than the general availability of nutrients in the soil, were responsible for the observed poor growth of crops in bad patches. Simply breaking up the soil mass, making it porous and thus improving the physical condition helped to increase the crop growth. It was further observed that rainfall stimulated the growth in the bad patches by destroying the adverse physical condition of the soil and after a good rain the carbon dioxide evolution rate in both good and bad patches was more or less equal. This further confirmed that the physical condition of the soil was the major factor of the poor growth of plants in these bad patches.

20. *Sampling technique for bacteriological work.*—It was found that sampling of a plot of 1/40th of an acre size could be accurately done by removing five samples of soil from different parts of the plots, four from 4′ to 5′ near the corners and one from the centre. Increase in number of individual samples to make a composite did not increase the accuracy commensurate with the trouble involved because only 0·000001 gm. Of the soil was ultimately used for plating or direct counting, and the sampling error involved in subdividing a large amount of soil was greater than that in subdividing a smaller amount. The initial lessening of the error by large number of samples was offset by ultimate large number of subdivisions it had to undergo before the final sample was made for the determination.

Personal error in these determinations were measured and it was found to be less than the variation in the method itself. So the method was expected to give accurate results with different individuals.

21. *Bacteriophage.*–Various plots in the farm area were examined and it was found, that the bacteriophage did not occur in fields growing berseem for the first two years but it did occur in the fields when under berseem for more than two years.

Pot culture experiments were started to see if the bacteriophage developed in pots growing different leguminous plants continuously for a number of years.

It was found that application of ammonium sulphate and super-phosphate favoured the development of bacteriophage. The growth of berseem in ammonium sulphate treated plots was thin while that in superphosphate plots was thick.

Further, bacteriophage developed after 2 years in peas, fenugreek, sweetpeas and berseem, while it took three years for khesari to develop it ; bateriophage was not present even after 3 years in lentil. The phage was very active in peas and berseem and active in sweetpeas. It was weak in the case of fenugreek and khesari. It would thus appear that active phage developed much earlier in legumes which were normally suitable for cultivation in the area than in legumes which did not habitually prosper in the place.

22. *Kodo grains.*—Earlier studies indicated that the wholesome and unwholesome character of grains may be associated with the morphological difference of two rows or multi-rows of spiklets in the rachis.

A new crop from two rowed and multi-rowed kodo grains was obtained and instead of carrying out experiments with rats, the grains were cooked in the village fashion and partaken by a batch of twelve individuals. Both the varieties were found to be quite wholesome and none of the symptoms that were noticed in the first year could be produced by the second year's crop. The experiment was repeated but without any positive results. This showed that the variety as such had little to do with the unwholesome character.

23. *Legume inoculation.*—Under advice from the Imperial Council of Agricultural Research the study of the effect of legume inoculation on yields of indigenous legumes was taken on hand.

24. *Isolation of sulphur producing bacretia.*—An organism was isolated which reduced sulphates in presence of organic matter to sulphur under anaerobic conditions. It was short, motile, rod-shaped organism, which did not form spores.

The cultural and biochemical characteristics of the organisms were determined. In liquid medium about 30% of the sulphate sulphur was reduced to elementary sulphur in about a week's time.

25. *Nutritive quality of grains raised with different manures.*—Exepriments were set up to judge the nutritive quality of wheat grown under the following treatments in the first instance in Pusa soil—

1. Green Manuring.
2. F. Y. M.
3. Complete artificials.

The growth curves of the set of albino rats showed that the best growth was obtained with green manured wheat closely followed by F. Y. M. wheat. Wheats raised with organic manure were very definitely superior to the wheat raised with complete artificials. One interesting point brought out was that uptil 41 days the growth curves under all feeding treatments did not show appreciable differences, but the differences became augmented slowly as the period of experimental feeding increased and after 72 days the differences in growth in different sets were very pronounced. This indicated that erroneous conclusions could easily be obtained if the experiments were not continued over a long period.

The rats fed with grains raised on organic manures gave litters while those fed on grains raised on artificials failed to produce. It was, therefore, not possible to study the effect of these diets on successive generations.

26. *Influence of Preservation of vegetables on Vitamin C contents.*—Investigation was started to find out if the vitamin C contents of vegetable decreased if preserved according to the method evolved in our laboratory of adding 2·5 per cent common salt and packing in airtight containers. Preserved cabbage was used as the test material. In seventeen days the guinea pigs eating preserved cabbage showed signs of acute scurvy, while the set getting fresh vegetables was quite healthy. This definitely showed that preserving vegetables with common salt affected its antiscorbutic properties.

27. *Calcium and phosphorous contents of milk and feeds in Sahiwal cows at Delhi.*—It was proposed to study the intake of Ca and P_2O_5 and the excretion of these elements in milk in the Sahiwal cows in the Dairy. The main purpose of the investigation was to find out how the inadequate supply of minerals in feed affected the health of cows by their drain in milk. For this purpose cows in different lactations and of different yielding capacity were included in the first selection. The result indicated that cows yielding more than 30 lbs. of milk per day were on the border line of negative balance of these minerals and feeds rich in Ca and P_5O_2 were necessary to keep them in best of health. The ratio of Ca : P_2O_5 was very high in pre-milk and gradually increased till the date of calving : after this it decreased and attained stable figure which remained more or less near the mark till the tail end of lactation. At the tail end it again increased. Large number of animals were kept under observation and it was proposed to study all the cows as they come in the cycle from the premilk stage.

28. *All India Soil Survey Scheme.*—The work under the Scheme started in December 1942 with the appointment of the Soil Survey Officer.

The collection of data in Bengal, Assam, Punjab, Sind, C.P. and Berar, Madras, U. P. and N.-W. F. P. were completed. From the consideration of the information collected so far it may be stated that the soil work in India has been directed to study the soil material for detecting manurial requirements and for characterisation of the material itself, while the essential requirements of soil survey as it is now understood in all progressive countries has not been touched upon.

III.—ANALYTICAL AND ADVISORY.

641 samples were analysed and reported upon in 1941-42 while 1248 were handled in 1942-43. Different samples of soils, water, manures and fertilizers, feeding stuff, butter, sugarcane juice, wheat (grain and straw), oil seeds, tobacco, pyrethrum flowers, artemisia, martitina, insecticides, weeds, cultures, urine, U. P. barleys (for malting quality), ghee, oils, bura, gur, fruit products and honey totalling 2,043 were analysed or identified during the year 1943-44 and the required advice was furnished.

REPORT OF THE IMPERIAL MYCOLOGIST

(B. B. MUNDKUR).

I. DISEASES OF PLANTS.

Wheat (Triticum vulgare Host).

Loose smut—*Ustilago tritici* (Pers.) Rostr.—These investigations, started in 1936-1937, made considerable progress during the years under report. Wheat varieties received from the Imperial Economic Botanist, Wheat Specialist in C.P., Cerealist in Punjab and the Director of Agriculture in Sind, were tested to see if they possessed any immunity or resistance to the disease.

Imperial Economic Botanist's wheats.—These were tested against two collections of smuts, viz. the Pusa collection and the Delhi collection, hereafter called L_1 and L^2 respectively. The results are given below :—

In 1941-1942, 27 varieties were tested against L_1 of which 22 did not take infection. Twenty one varieties were tested against L_2 of which 15 did not take infection. A few varieties showed a high degree of resistance.

In 1942-1943, 51 varieties were tested against L_1 of which 22 again did not take infection and twenty three varieties were tested against L_2 of which eleven were found to be free from infection, a few showed considerable amount of resistance.

In 1943-1944, 66 varieties were tested against L_1 of which 36 did not take infection. One hundred and one varieties were tested against L_2 of which 31 did not take infection and a few were highly resistant.

Some of the varieties tested in the above investigations have consistently remained free from infection for several years and there is no doubt that they possess immunity to loose smut.

Physiological specialisation in loose smut.—The use of Canadian differentials for identifying the physiological races of loose smut did not give satisfactory results and certain Indian wheats were therefore selected to serve that purpose. Results obtained in 1943-1944 showed that there may be two physiologic races in India but this has to be confirmed by further work.

Karnal Bunt.—*Neovossia indica* (Mitra.) Mundkur.—Several experiments were laid out in 1941-1942 and 1942-1943 to determine the mode of transmission of this disease without a knowledge of which it is not possible to devise measures for it's control. In the latter year more or less convincing evidence was obtained that the disease is not systemic but local and air-borne. In 1943-1944 several hundreds of ears were infected both at Delhi and at Simla at the flowering time and it has now been definitely shown that the disease is air-borne. The sporidia which are produced in abundance in the month of January and February when the day and night temperatures are cool, infect the wheat ears and bring about the disease.

Flag smut—*Urocystis tritici* Koern.—Reaction of wheat varieties to this smut which is externally seed-borne, was tested during the period under report. In 1942-1943 when abundant inoculum became available, 129 varieties were tested of which 53 took no infection, 19 only slight infection, while the rest showed high infection. Similar results were obtained in 1943-1944 also.

Barley (*Hordeum vulgare L.*)

Covered smut—*Ustilago hordei* (Pers.) Lagerh.—In order to devise measures to control this smut experiments were laid out at Karnal and at Delhi. Two year's trials have shown that sulphur dust of extreme fineness or dust made from Baluchistan sulphur ore, is able to considerably check the disease.

Jowar (*Sorghum vulgare Pers.*)

Grain smut—*Sphacelotheca sorghi* (Lnk) Clinton.—Crude Baluchistan sulphur of 60 or 75 per cent purity, ground to pass through a sieve of 100 mesh per linear inch, was compared with pure sulphur, formalin dust (6 per cent. formalin on charcoal dust) and Agrosan G at a dosage of 1 : 250 by weight. Results have shown that Baluchistan sulphur is at least as good as pure sulphur and only very slightly, if at all, inferior to Agrosan G.

Pigeon pea (*Cajanus cajan* (*L.*) *Millsp.*)

Wilt—*Fusarium udum* Butler.—Experiments to determine the resistance of pigeon pea varieties to *Fusarium* wilt were continued. In 1941-1942 pot experiments with this disease were not successful but a method was later devised to get over this difficulty. In 1942-1943, 20 varieties supplied by the Imperial Economic Botanist were tested. Nineteen of these varieties were infected from 79 to 100 per cent but the remaining one variety, A. 126-4-1, failed to take infection. These were again tested in 1943-1944; IP 80, IP 41, C. 38, C. 15, A. 126-4-1, D. 16-17-2 pt. 12 and D. 33-4-22 proved to be resistant. Six varieties from Coimbatore were also included in the experiments but all of them, including Bulsar White (reputed to be resistant), fared badly.

A plot in which cultures of the fungus grown on soil-maize meal medium were periodically added and infected debris was ploughed in every year, was used to test the resistance of some of the pigeon pea varieties to wilt on a field scale. The varieties IP 80, IP 41, C. 38, C. 15 and A. 126-4-1 maintained their resistance while IP 69, a known susceptible variety, showed 78 per cent infection.

Gram (*Cicer arietinum L.*)

Wilt—*Fusarium orthoceras* var. *ciceris* Padwick.—Experiments on the effect of date of sowing on the incidence of wilt were conducted for the fourth and fifth successive seasons. September sown crop was practically destroyed by wilt but in October sowings wilt was very appreciably reduced. In 1943-1944 the amount of wilting was observed in the experiments conducted by the Imperial Agriculturist to determine the effect of grom yield of various manurial treatments, mulching, flooding the land in August or September. As the year was a bad ' wilt ' year, the highest incidence of wilt being only 9·1 per cent, the results must be concluded as inconclusive.

Foot-rot—*Operculello padwickii* Kheswalla.—Isolations were continuously made during the season from ' wilted ' plants and in several cases *Operculella padwickii* has been invariably isolated. In 1941-1942, 32 varieties were tested for resistance to foot-rot in pots, and the test repeated the next year. No clear case of resistance to the disease was noticeable. Date of sowing tests indicated that even with this disease, early sowing is detarimental to the crop. *Trichoderma*

lignorum (Tode) Hayz which is known to have an adverse effect on the growth of certain parasitic fungi was mixed with the soil highly infected with *Operculella*. No reduction in infection was observed over a period of three years. In 1943-1944 the experiment on date of sowing had superimposed upon it a test to see the effect of vernalised and non-vernalised seed on the incidence of the disease. The usual decline in wilt with later sowings resulted with both the seed, the general level of infection tending to be somewhat higher in the latter than in the former case.

Potatoes (*Solanum tuberosum L.*)

Late blight— *Phytophthora infestans* (Mont.) de Bary.—In 1941-1942, the fungus was brought into culture, growth being particularly good on carrot extract agar. But the culture was lost due to a breakdown in the refrigerator. The fungus was then treated as though it were an obligate parasite and was maintained on its host throughout the year. In 1942-1943, therefore, 241 varieties and hybrids could be tested for their resistance. Thirty seven varieties did not take infection, being either immune of highly resistant, and the remainder proved to be highly susceptible. In 1943-1944, 243 varieties and hybrids were tested, of which 61 varieties proved to be highly resistant. These tests are in progress.

Early blight—*Alternaria solani* (Ell. and Mart.) Jones and Grout.—Beginning in 1942-1943, tests to determine the resistance of potato varieties to early blight were taken up, 12 being tried in that year. Only one variety showed any resistance. No tests were carried out in 1943-1944.

Storage rots :—*Fusarium solani* (Mart.) App. and Woll:—This fungus was found to be causing severe rotting of potatoes both in the field and in storage at Simla; a highly sporing isolate was obtained. In 1941-1942, fifty varieties were submitted to the resistance tests by spraying the tubers with a suspension of the spores and placing them in a moist chamber. They varied from complete susceptibility to a very high degree of resistance. In 1942-1943 the optimum temperature for infection was determined and found to be 25°C. Infection took place rapidly also at 20° and 30°C, but at 35°C and above bacterial rotting set in, and at 15°C and below infection was exceedingly low. In 1943-1944 tubers of 60 varieties and hybrids were tested. Seven varieties showed no infection and five less than ten per cent. The remainder showed infection ranging up to 100 per cent.

Virus diseases.—In 1941-1942 the incidence of potato virus diseases at Delhi was recorded from week to week. It was noted that in the spring crop, virus infection was at its highest from the first week of February to the middle of March and lowest after the third week of March indicating masking of symptoms. In 1942-1943 it was found that in the winter crop there was practically no masking. Differentials for the detection of viruses were multiplied regularly and with their help *Solanum* virus *I*, *II* and *III* were isolated from several varieties, while indication of at least two other viruses was obtained. *Solanum* virus I recovered from potato plants of different varieties was found to be divided into four different groups on the basis of reactions on the differential hosts. Attempts made to secure virus free material of standard commercial varieties resulted in obtaining a small quantity of " Darjeeling Red Round " variety free from virus. In 1942-1943 loss in yield of *Phulwa* variety of potatoes, due to the various kinds of mosais, was carefully calculated. The results are given below :—

Type of mosaic.	Loss in yield percentage.
Negligible	25·5
Borderline mild	45·1
Borderline severe	73·5
Severe	92·3

Certification of seed potatoes.—In 1941-1942, steps were taken to find out localities, if any, where the crop can be grown with a minimum of natural spread of virus diseases; an extensive survey was started for the purpose. Incidence of virus diseases in the Himalayan foot-hills was found to be considerably lower than on the plains, and the type of infection was less severe. In the Darjeeling hills, at altitudes of 5 to 7 thousand, negligible type was more predominant and infection varied from 84 to 93 per cent. In the plains of Bengal, infections varied from 79 to 91 per cent; in Bihar, it varied from 25 to 35 per cent, and in the United Provinces, from 34 to 98 per cent in the first crop, and 30 to 88 per cent in the second crop.

A note on the incidence of aphids was also kept. It was markedly less in the higher hills than on the plains, rarely exceeding 4 per 100 leaves in the former, and reaching as high 417 per 100 leaves in the plains.

Further attempts were made in 1943-1944 to secure nucleus disease free seed of important commercial varieties; three acres were planted at Dehli and at Karnal with seed obtained from a number of localities; infected plants were rogued out as they appeared. The tubers from the few remaining plants were planted at Kufri (8000 ft. above sea level) which has been selected as the site for the Central Station for Seed Potato Certification.

Tomatoes (Lycopersicum esculentum Mill.)

Virus diseases.—An experiment was laid down in 1941-1942 to determine the loss in yield of fruit due to virus diseases, reliance being placed on natural infection. Plants were classified according to symptoms and the average yield per plant, on the basis of an average of 100 units for healthy plants was as follows:—

Symptoms	Yield in units.
Healthy	100·0
Mosaic	89·2
Necrosis (?)	46·0
Leaf-roll	15·8
Mosaic + leaf-roll	26·8
Leaf-roll + necrosis (?)	1·1

Evidence of marked differences between varieties as regards susceptibility to virus diseases was found. A study of the complex of virus diseases known locally as ' leaf-curl ' was made. In 1942-1943 its incidence was appreciably lower than in previous years. By varying the sowing date from September to November it was noted that there was a gradual decline in the incidence of the disease. By broadcasting gram between the rows of tomato plants, it was found that the diseases could be checked to an appreciable extent, there being 8·1 per cent in the mixed crop as against 33·4 in the regular crop. In another experiment two sprays were given in the nursery and one after transplanting to the standing crop in the field, with nicotine sulphate and soft soap for two successive years, but infection could not be reduced, though the incidence of the insects showed a decline.

In 1942-1943 two plots were sown with Sutton's Early Market variety of tomatoes. Plants that showed symptoms of disease were immediately rogued out and replaced with healthy seedlings, the other plot where no rogueing was done, served as a control. The former plot yielded 68 per cent more fruit, by weight, than the latter. In view of the small cost of raising tomato seedlings, this offers a practical means of overcoming serious losses.

An abnormal condition resembling ' Big Bud ' in tomato plants was observed for the first time in this country and the virus causing the disease has been identified as *Lycopersicum* virus 5.

Sugarcane (Saccharum spp.)

Red-rot —*Colletotrichum falcatum* Went.—In 1941-1942 a particularly virulent strain of this fungus was isolated and 79 varieties were inoculated with it. Thirty-six proved to be moderately resistant, 30 moderately susceptible and 13 were highly susceptible. In the resistant varieties, the reddening caused by the fungus was not more than 15 inches but in the susceptible ones, it spread to over 30 inches, maximum being 60 inches. In 1942-1943, 98 varieties were tested and a moderate degree of resistance was shown by 22 varieties. In 1943-1944, 116 varieties were tested and 22 varieties proved to be moderately resistant.

Modes of transmission of red-rot.—Experiments to determine the modes and sources of infection clearly established that infected debris in the soil and irrigation water in which the spores are present can bring about infection. Young and old uninjured nodes also afforded entry to the fungus, thus disproving the view held previously that to successfully control red-rot it was enough to use clean setts.

Physiological specialisation in *Colletotrichum falcatum* Went.—The occurrence of a light coloured, highly sporing and virulent strain of *Colletotrichum falcatum* in the areas where red-rot occurred in epidemic proportions led to the suspicion that there may be parasitic races of this fungus and experiments were started to find if such was the case in 1941-1942. A large number of isolations that were made showed that there are principally two races, a light race referred to above and a race with dark coloured mycelium. While the former was highly pathogenic, the later was less so. Among the light coloured races, there were, however, some isolates which were weakly pathogenic and in the dark coloured race, some isolates were encountered which appeared to be more virulent.

Wilt—*Cephalosporium sacchari* Butler.—Varietal resistance tests with this fungus were carried out in 1941-1942 and 1942-1943. Eighty four varieties were tested in the former, and 95 in the latter year. Forty five varieties showed some resistance (linear spread of infection being less than 6 inches), 26 were moderately infected, and 13 susceptible (reddening more than 15 inches) in 1941-1942, while in 1942-1943, 60 varieties showed very little infection.

Smut—*Ustilago scitaminea* Syd.—Both temporary and more lasting methods of controlling this disease were examined during the period under report. Immersing the infected setts in hot water, at various temperatures, yielded promising results but considerable injury to germination was, however, caused. Systematic rogueing and seed selection for three successive seasons have been found to completely control the disease.

Varietal resistance tests.—In 1941-1942 varietal resistance tests were conducted with 74 varieties of which 30 varieties showed less than five per cent infection, 33 varieties being intermediate in reaction, and the rest susceptible. In 1942-1943, 107 varieties were tested; of these 21 had less than 15 per cent infection. The same number of varieties was tested in 1943-1944 of which 17 had less than 15 per cent infection. Experiments conducted to see if there was any parasitic specialisation in the fungus did not give any conclusive results.

Ergot of Grasses

Ergot—*Claviceps purpurea* (Fr.) Tul.—This fungus of economic importance had not been recorded from India before. It was found to be abundant, however, on three wild grasses in Simla, viz. *Brachypodium sylvaticum* Beauv., *Andropogon* sp. and *Oplismenus compositus* Beauv. The ergots on the first two proved to be *Claviceps purpurea* and a new species, *Claviceps virescens* Padwick and Azmatthullah was established for the reception of the ergot on the last named grass.

Rice (Oryza sativa L.)

Sesame leaf-spot or leaf-stripe—*Helminthosporium oryzae* Breda de Haan.—Reputed failures of well known seed-dressings to control this disease, which however, control the leaf-stripe diseases of other cereals, led to a thorough examination of specimens of infected leaves and seeds to determine whether the disease is really due to *Helminthosporium oryzae*. It was found that just over a quarter of the specimens obtained from all over India showed the presence of *Helminthosporium* whereas over one half showed the presence of *Curvularia* as shown below :—

Province	No. of diseased samples examined	Number showing Helminthosporium.	Number showing Curvularia
Assam	142	39	57
Bengal	113	17	43
Bihar	6	0	0
Orissa	45	4	2
Madras	348	116	233
Sind	6	0	0
Total ..	660	176	335

II. INDUSTRIAL MYCOLOGY AND BACTERIOLOGY.

Curing of hides.—A good deal of edible salt is used in the curing of hides. In order to conserve as much edible salt as possible, the possibility of using impure bittern salts from Sambhar lake was examined. Naturally formed bitterns salts from partially exhausted mother liquor are contaminated with aerobic bacteria and, if used in the curing process, cover the hides with a red, foul-smelling slime causing a red discolouration of the hides, known as " red-heat ". Manufacturing bittern salt by depositing it out in the same clean pans that are used for crystallising out the edible salt, resulted in a better product but if denatured with Chlorazol blue and kerosene, proved to be the best from the curing point of view, giving a clean hide. Taking into consideration, however, that rapid and often heavy infestation of even mined salt takes place when exposed to commercial storage and transport conditions, it was decided that manufactured bittern salt, despite the presence of chromogenic halophilic bacteria is serviceable for curing and pickling hides, and thus conserve edible salt for human consumption.

Baluchistan Sulphur.—The possibility of using the crude sulphur ore, mined in Baluchistan, as a seed dressing to control seed-borne diseases, after the ore is pulverized to an exteremely fine powder, was investigated. It was found to be as good as pure sulphur in controlling externally seed-borne diseases, like barley covered smut and grain smut of jowar.

Indian Type Culture Collection of Fungi.

This collection, started in 1936, was gradually built up by obtaining cultures of fungi, useful in fermentation and other industries and fungi of academic interest, from abroad and also by direct isolation of fungi and their identification. In 1943, the Imperial Council of Agricultural Research gave a two years' grant which enabled the employment of an Assistant to devote his attention exclusively to this work. Due to the courtesy of the Fermentation Division of the North Regional Research Laboratory, Peoria, Illinois and the Imperial Mycological Institute, Kew, several authenticated cultures were added to the collection. Requests received from the provincial mycologists, university professors of Botany, industrialists and others for fungal cultures of economic and academic importace were complied with.

III. TAXONOMY.

Taxonomic work centred especially during the year on smuts, rusts and the genera *Fusarium* and *Synchytrium*. Other genera on which work was done included *Choanephora*, *Oidiopsis*, *Pestalotia*, *Monochaetia*, *Phyllosticta* and some downy mildews. The work is recorded in detail in published papers.

IV. MISCELLANEOUS.

Advisory.—Six hundred and nine specimens of diseased plants were examined and reported upon for officers of Departments of Agriculture and university professors during the period. One hundred and fourteen cultures were identified for workers in India. Thirty papers intended for publication were referd. Eight technical notes were prepared for agricultural departments, institutes and workers.

Mycological Conference.—An All-India programme of research in Mycology and Plant Pathology was drawn up at a conference of selected mycological workers in India over which the Imperial Mycologist presided. The conference considered the problem of co-ordinating mycological research. The conference was convened at the instance of the Imperial Council of Agricultural Research.

Herbarium.—Seven hundred and nine specimens were added to the Herbarium and 341 specimens were supplied to workers outside the Institute.

REPORT OF THE IMPERIAL ENTOMOLOGIST

(H. S. Pruthi.)

I. INTRODUCTION.

The direction of locust compaign in India continued to engage the Imperial Entomologist. As locust pest is not only of all-India but of International importance, it is essential that all provinces and states should take adequate control measures on a co-ordinated plan. To achieve this object, representatives of various provinces and states met in a conference convened by the Government of India at Delhi in April 1942 and approved of a Scheme under which expenditure incurred in all desert outbreak areas, that were scheduled, was to be allocated to all the beneficiary provinces and states irrespective of the fact whether breeding took place in them or not. This Scheme was to be administrered by the Government of India and put in charge of the Imperial Entomologist. As locust situation in Iran and Arabia is of great concern to India, four Locust Delegations were sent to these countries during the period under report. The Imperial Entomologist attended International Locust Conferences held at Tehran in October 1942 and at Cairo in June-July 1943.

II. CO-ORDINATION OF ENTOMOLOGICAL WORK IN INDIA.

Considerable time was given to the examination of current Entomological research programmes of various provinces and states, and a report on the Co-ordination of research in Agricultural Entomology in India was prepared. At a conference of workers held in July, 1944, all of the main proposals were accepted.

III. SPECIAL INVESTIGATIONS.

1. Insect Vectors of Tobacco Leaf-Curl.

Experiments carried out earlier at Pusa had shown that fish oil rosin soap, sprayed four times at weekly intervals in the nursery and in the field on plants from the time they were about 6-8 weeks old, satisfactorily controlled the white-fly (*Bemisia tabaci*) transmitter of leaf-curl disease. Field trials on a large scale were made with various insecticides during two seasons of 1941-43, and these confirmed the results obtained previously. As a result of sprays, the disease was reduced to the extent of 40%.

2. Insect Population Studies.

Observations on the oscillation in the population of spotted bollworms were started at Karnal in the autumn of 1941, under a special scheme of research. Attention was directed chiefly to develop a standard method of evaluating the population of insect and of analysing the various factors affecting the population. An examination of various statistical methods of field census have shown that data on incidence of bollworms, collected in the ordinary way, are not sufficiently reliable for an ecological interpretation, unless the population per unit areas or volume is considered. Thus the highest percentage incidence of spotted bollworms during three seasons, 1941-42, 1942-43, 1943-44, was 10%, 5% and 21% respectively whereas the highest population per acre for three seasons work out to be 23,000,20,000, and 22,000. Thus percentage incidence data would have indicated undue apprehension in 1943-44 and given false sense of security in 1942-43. Two instruments, Biograph and Biometer, were devised to give correct idea of the duration of life-cycle under any range of temperature.

3. Pests of Stored Food-Stuffs.

(*a*) *Pests of Stored jowar.*—Studies on the incidence and biology of important insect pests of jowar were started as a part of a Scheme of the Imperial Council of Agricultural Research from April 1942. As a result of surveys conducted in various parts of India, it has been found that about a dozen insects do appreciable damage to stored jowar and of these the important ones are *Sitophilus oryzae*, *Rhizopertha dominica*, *Sitotroga cerealella*, *Corcyra cephalonica*, *Tribolium castaneum*, and *Silvanus surinamensis*. It has been determined that moisture contents of the grain has a great influence on the incidence and development of the pests, that when the moisture contents are low, 7% or less, these pests become sluggish and die soon, but at moisture contents of 12% or more they breed well. Heat sterilization experiments show that 15 minutes heating at 55°C. killed all pests but the seeds were not affected. A large number of inert dusts and chemicals have been tried as preservatives and of these calcium carbonate (1 : 200) has given the best result.

(*b*) *Pests of dry-fruits and nuts.*—From an examination of numerous sample received from military and other sources, it has been found that the major pests of dry fruits are *Tribolium castaneum*, *Rhizopertha dominica*, *Limophloeus* sp., *Sitotroga cerealella* and *Corcyra cephalonica*. A simple and effective method of preserving dry fruits has been found to be superheating, an exposure of infested fruits for 35 minutes to 48°C. and 85 minutes to 46°C., for example, killed all these pests.

4. Pests of Fruits and Vegetables.

(*a*) *Biology and control of Bagrada picta.*—Observations on the biology of this pest were continued. Contrary to the previous view, eggs were found to be laid in the soil and not on plants. It was observed that there were four generations of the pest on *toria* from October to March, after which it migrated to wild host plants such as *Gynandropsis pentaphylla*, *Palanisia viscosa* etc. Spraying the crop with kerosine emulsion gave good results and reduced the attack by 30%.

(*b*) Various fruit flies attacking cucurbits continued to be under observation.

5. A Pest of Wheat New to India.

At the request of the Director of Agriculture, Baluchistan, some observations were made on *Eurygaster maura*, a pest of wheat in Europe, that was reported to be causing considerable damage in Zhob valley. The nymphs and adults of this bug attack the ripening ears or even the spikelets, and as a result of the attack the young shoots and flowering parts are killed and older plants become etiolated. At one place, Kohlu (Sibi District), over 90% of the crop was killed. A critical examination of a large collection made has shown that five distinct varieties of *E. maura* are found.

6. Biological Control of Pests of Sugarcane.

The central part of the Scheme for research on insect pests of sugarcane, which started in August 1936 was wound up in March 1942. Instead a revised Scheme, which had for its object critical trials of some already known methods of control was started with centres selected in (*i*) Punjab, (*ii*) U.P., (*iii*) Bihar, (*iv*) Hyderabad (Deccan) and (*v*) Madras. The Biological Control part of the original scheme was further extended and seven centres were selected for *Trichogramma* colonization experiments. Out of the seven centres selected, three centres were under the direct supervision of the Imperial Entomologist. Further, the Imperial Entomologist was entrusted with the work of planning and coordination of research work for both the schemes.

At New Delhi, in addition to mass-breeding of *Trichogramma* ecological studious on this and some other parasites were taken up. It was found that the most suitable temperatures for rearing *Corcyra* sp., and *Trichogramma* were 74°F. to 78° F. and relative humidities of 50% to 60%. 150 million *Trichogramma* were produced in the laboratory during 1942-44. Supplies of this parasite were made to Lyallpur, Bombay, Meerut, Ranchi, Pusa, Bhopal, Cuttack and Setabgunj where it was liberated in sugarcane fields to reduce the attack of borers.

Further observations on the life-history of a number of parasites, *Stenobracon deesae*, *Elasmus zehntneri* and *Melcha ornatipennies* were made. A large collection of hibernating larvae of the last named parasite was made and it was found that the best way of breaking diapause was to subject the larvae to a temperature of 86°F. and 3 mm. saturation deficiency. At 50° F. the parasite failed to develop and at 59°F. it went into hibernation in the prepupal stage.

Conservation of egg parasites of *Pyrilla* after removal of eggs, and the removal of eggs alone were found to increase the yield of sugarcane appreciably as compared with control plots. Trials are in progress to study the sap concentration and incidence of this pest in plots treated with various manures.

7. Insect Pests of Potato.

Insects attacking potato in the field and in storage continued to receive special attention. The life-history of three important sucking insects, namely *Empoasca kerri* var. *motti*, *Megacoelum stramineum* and *Myzus persicae*, were studied in detail and their host plants recorded. *E. kerri* was quite common throughout the season; nymphs and adults feed usually on the under side of the leaves. During winter months the life-cycle was completed in one month's time. *M. stramineum* was common from October to December, it completed the life-cycle in four weeks time. *Myzus persicae* was recorded from 31 host plants belonging to 14 different Natural Orders. No oviporous females were found, nor have they been recorded so far from any part of India.

The problem of storage of potato in the centres of production for varying periods, under the stress and strain of War, necessitated a critical study of the various insects attacking stored tubers, specially *Gnorimoschema operculella*, with a view to devising effective control measures. This moth lays eggs on the tubers, most profusely at a temperature of about 81°F. and 100% relative humidity, and as many as 12 generations are completed in a year. If potatoes are stored under dry conditions, the moths do not lay eggs and the larvae cannot also penetrate more than a layer of 1" in depth. Of the various fumigants tried against infested tubers, carbon disulphide (1oz. per 2 c. ft. of store-space) was found to be most effective.

8. Insect Pollinators of Berseem Flowers.

To ascertain whether the cause of absence of seed setting in berseem could be attributed to the absence of suitable insect pollinators, all the insects visiting the flowers of berseem throughout the day and night were collected, and detailed observations regarding the activity in pollinating the flowers were made. Collections of insects from berseem flowers at Pusa were also under study. Some preliminary observations showed that *Apis indica* plays an important role in the pollination of the flowers.

9. Termite Control.

The study of methods of control of termites damaging sugarcane setts was initiated in 1941. The experiments were carried out at Karnal with setts treated with paris-green, lead arsenate, arsenic, coal-tar and coal-tar-soap-emulsion. A month after treatment the maximum attack of termites was confined to the control sets and those soaked in water prior to sowing. Treatments which gave promising results were, in the order of their efficiency (*i*) corrosive sublimate sol. (*ii*) Coal-tar (diluted) (*iii*) paris-green suspended in coconut oil.

A large collection of termites—adults, soldiers and workers—from the environs of Delhi, was made to determine the common species found. While making these collections, it was observed that the grubs of two beetles, *Gonocephalum depressum* and *Rhitonata impolita*, were predators on the workers of termites about 3 inches below the surface of the soil.

10. Anti-locust campaign in India and neighbouring countries.

In my report for 1940-41 the initiation of a fresh locust cycle in the summer of 1940 was reported, and the subsequent over-wintering and breeding of locust in the spring and early summer of 1941 was described. The waves of foreign swarms which were received in June-July 1941 laid eggs on vast areas in Rajputana and the locust underwent two generations by the middle of November. The swarms crossed the permanent breeding areas and invaded western parts of United Provinces, northern parts of Central Provinces and southern and western districts of the Punjab reaching the N.W.F.P. in the north. The damage done to *Kharif* crops was, however, not much because the local authorities had been given warning in time and they had taken suitable measures to prevent heavy damage. In October the western migration of swarms started and whereas some flew towards the hilly tracts of Baluchistan and others crossed apparently into Persia, majority of the swarms which were overwintering in Baluchistan and other parts of north-west India got perished due to excessive cold early in 1942. In spring of 1942 rainfall was quite heavy in Baluchistan, but due to comparatively lesser locust concentration breeding in Mekeran and the interior of Baluchistan was light. Necessary control measures were taken in all parts of Baluchistan and no incipient swarm was reported from any locality.

The representatives of various States and Provinces met in 1941 and again in 1942. As a result of these conferences a Co-ordinated Scheme of Locust Control was approved. According to this scheme the expenditure on locust control work to be carried out in scheduled desert out break areas was to be pooled at the end of the season and allocated to various target areas of the swarms. For this purpose the target areas were divided into three categories depending on their distance from the danger zone, and the shares of the various beneficiary target areas were fixed on the basis of their culitivated areas and in the ratio of $2:1\frac{1}{2}:1$, the areas closest to the danger zone paying the maximum. The scheme was under the technical charge of the Imperial Entomologist. For this purpose a special Inspectoral staff distinct from the Locust Warning Organization was sanctioned for rendering all possible technical advice and ensuring that adequate control measures were taken in all parts and for advising the locust control officers of various Provinces and States with regard to the expenditure to be incurred. The Locust Warning Organization was also further strengthened in April 1942 to ensure better intelligence work.

About the middle of May 1942, there was distinct rise in the locust population specially in Mekran due to the infiltration of a number of locust specimens . During the first fortnight of June actual swarms coming from west (i.e. Persia) were observed in Mekran (Baluchistan) and thence they spread into Sind, Punjab, whole of Rajputana, Western India States, Central India States and United Provinces. The eastern most locality reached was near Allahabad, the southern most near Baroda and northernmost Nabha State in the Punjab. As there was no rainfall in Sind and Western Rajputana during June, the swarms simply passed over and laid eggs in eastern Rajputana and western parts of United Provinces where the rains were received. Control work was carried out in all areas, but work in certain parts of Jaipur, Jodhpur and Jaisalmer was not very good for several causes. The first generation of home-bred adults developed by the middle of August. They were supplemented by further immigrations from the west. By this time the western Rajputana, Bahawalpur and Khairpur, etc., had also received sufficient precipitation and the swarms invaded these parts and laid eggs on a large scale. Unfortunately the control work continued to be unsatisfactory in parts of Jaisalmer State and in Khairpur State due to Hur trouble. Consequentely several swarms developed. They flew mostly towards north and north-east though some flew towards west also. Of the latter, about half a dozen left India for Persia after the middle of October. Of the former, many entered the hills and died due to excessive cold and some overwintered in the Punjab and Sind, etc.

During February 1943 oviposition took place in northern Punjab and western Sind and control operations were carried out by the local administrations. Some hoppers escaped destruction in Cambellpur district (Punjab) and the resultant adults penetraed into N.W.F.P. and led to the late-spring breeding. The breeding in Persia continued throughout spring months and upto the middle of July, and a large number of hoppers escaped destruction there. The first wave of swarms originating there reached Baluchistan in the first fortnight of April followed by a second wave towards the end of May and subsequent incursion of swarms continued up to August. Large scale egg-laying commenced by swarms coming in April in Mekran, Jhalwan and Kharan states and Chagai district, but effective timely control measures were taken and no swarm allowed to develop.

The numerous immigrant swarms that came from May onwards started laying eggs after the commencement of mousoon rains, from the second week of June. Egg-laying was first reported from Jodhpur and Barmer districts of Jodhpur state, and parts of Jaisalmer, Bikaner and Jaipur states. During the second week of July there was heavy and well distributed rainfall in Sind and Rajputana deserts and this was followed by egg-laying in Thar Parkar district (Sind), almost whole of Jaisalmer and Bikaner states and in parts of Jodhpur, Jaipur and Bhawalpur states. Further egg-laying took place in some districts and states in the South-east Punjab and in parts of Bhawalpur state from about the end of August to the middle of September.

Energetic control work, based on trenching, baiting with sodium fluosilicate and burning, was carried out almost everywhere and most of the hoppers destroyed in early stages, i.e. much before they could acquire wings. Only about half a dozen small

swarms developed during September. They flew towards north-west, and got scattered and reduced by enemies, so that after 12th November no swarm was reported nor was any swarm observed to have penetrated into Mekeran or crossed the Indian frontier to enter Perisa.

Thus no swarm over-wintered in Baluchistan or any part of India. Towards the end of March 1944, however, Baluchistan was invaded, once again, by swarms coming from west or south-west Arabia. This immigration continued up to the end of June. These swarms laid eggs freely in various parts of Baluchsitan and also at some places in Sind. Control operations were promptly undertaken and were very successful ; only a few small swarms developed from some of the inaccessible localities. At about the same time breeding was in progress in Southern Afghanistan bordering Chagai district and Kharwash area of Persia bordering Kharan State. The resultant swarms entered India via Quetta district and Kharan respectively. The immigrant and some indigenous swarms started crossing Indus early in June and invaded Sind and Rajputana deserts and parts of Southern Punjab.

The Locust expert committee met in April 1943 and 1944 and further extended the coordinated Anti-locust Scheme ; they also strengthened the Locust Warning Organisation. The post of one Deputy Locust Entomologist was created from May 1943 and of another similar officer from May 1944. In 1943 the War Department placed 2 dozen lorries and sufficient camp equipment for control work and in the begining of 1944 agreed to loan troops for locust work in sparsely populated areas and aeroplanes for reconnaissance work.

11. Studies on House-fly and other Diptera.

The Second Entomologist (Dipterist), Mr. P. V. Issaac, attended mainly to work on Diptera and pests in dehydrated meat and fish. Systematic and regular collections of the house-flies occuring at Delhi were made. From the collections made, it was seen that the largest number of house-flies appears in August when it is hot and humid, and the lowest number in January when the lowest minimum temperatures occur. Throughout the year *Musca nebulo* ad *M. vicina* are the most abundant species. *M. vetustissima* and *M. yerburyi* occur in small numbers throughout the year, while *M. pulla* and *M. ventroza* occur in very small numbers from August to October.

Over 90% of the house-flies around human dwellings breed in accumulations of dung and garbage. The commonest house-flies, *M. nebulo* and *M. vicina*, seem to prefer cow-dung and house-hold refuse to horse-dung. The latter, it is observed, develops a temperature of 122°F. in about 4-7 days which is not suitable for the development of these flies, while cowdung and house-hold refuse develop lower temperature of about 100°F. and 830°F. respectively and serve as suitable media for the development of the flies.

A method was developed of having all the daily refuse of dung and litter put in a pit made to take a week's refuse. After the seventh day's refuse had been put in, the pit was sealed with earth covering applied in 3 successive layers, each layer 4 inches thick, well pressed down and the top 2 inches watered, slushed and plastered down. By this method all maggots were killed in 6 hours. Experiments repeated in 1943-1944 showed that when thus sealed in pits, the maggots are paralysed in one hour and in all take 6 hours to die. It was noted that even in wet weather the method could be employed with complete success provided the earth used for covering

up the pit is not oozing wet. The dung thus buried formed excellent manure. The method was found cheaper than the old method (in which many flies emerged) of putting dung into pit every day and covering the top with 6 inches of earth well rammed down.

Another method of control employed was to spread cow-dung, less than 24 hours old, in layers 2 inches or less thick in the field in the sun. There was no egg-laying after the dung had been spread and maggots found in this dung from previous oviposition died before they were 3 days old.

To help in the war, information was given to Burma Government on blood-sucking flies of Burma and house-fly control. At the request of Department of Food, the pests in dehydrated meat and dehydrated fish were investigated into and advice regarding their control given.

12. Scheme for the Survey of Icerya Purchasi.

A scheme for the survey of the well known insect *Icerya purchasi* in the Peninsular India started on 1st July 1943. As a result of the surveys undertaken, this pest has been found for the first time (*a*) at Bangalore, Mysore, Krishnarajasagar and on Nanda Hills in Mysore State, (*b*) at Tallar, Munnar, Devikolum in Travancore State, (*c*) in parts of Nilgiris and Salem districts of Madras Presidency and (*d*) at Poona in Bombay Presidency.

Of a large number of hosts plants found, the pest has been recorded for the first time from 8 plants. A number of coccinellids have been observed preying on this pest. Of these the more important are several species of genus *Rodolia*.

Four species belonging to genus Icerya—*I. aegyptiaca I. sychellarum, I. pilosa* var. *nardi* and a new species so far unrecorded, have been observed during the course of these surveys and information regarding their distribution and host plants has been obtained. Three other coccids, sometimes mistaken for the pest, were also observed.

The San Jose Scale (*Quadraspidiotus perniciosus*) was noted at Connoor, Kotagiri and Ootacamund on the Nilgiri Hills on apple, near and apple trees in Shevatory Hill and Salem district. At no other place, surveyed for *I. purchasi*, was this pest recorded.

13. Insecticides and Fumigants.

Experiments to test the efficacy of a number of insecticides of indigenous origin were carried out. Laborartoy tests with an aqueous extract of seeds of *Thevetia nerifolia* were carried out against *Laphygma exigua, Plusia orichalcea, Agrotis ypsilon, Aphis laburni* and *Macrosiphum solidaginis*. It was found that 1 : 20 dilusion gave about 80% mortality when the first 3 stage larvae of *L. exigua* and P. *orichalcea* were fed upon leaves dipped in the dilution, whereas no effect was observed on the remaining stages or on the aphids.

Tests with aqueous solution of zinc arsenate (11 lbs. in 100 gallons of water) mixed with lime proved effective in killing the third and forth instar larvae of *Agnais ficus* and third instar larvae of *Anomis flava* in 24 hours. The same insecticide was also effective against first and second stage larvae of *Ocinara varians*.

14. Taxonomic Studies.

Indian Jassidae, parasitic Hymenoptera and aphids were under special study

15. Observations on Insects of Economic Importance.

Detailed survey of the insect pests on crops were carried out in Delhi and the neighbourhood. The following were some of the more important insects which appeared in a pest form during part of the period under report :—*Amsacta moorei* on cowpeas, maize and jowar ; *Antigastra catalaunalis* on sesamum ; *Argyria stictic-raspis* and *Pyrilla perpusilla* on sugarcane ; *Bagrada picta* on cruciferous crops ; *Chilo zonellus* on jowar and maize ; *Earias* spp., and *Anomis flava* on cotton and bhindi; *Euproctis lunata* on castor ; *Heliothis armigera* on lucern ; *Hellula undalis* and *Rhopalosiphum psuedobrassicae* on cabbage and cauliflower ; *Laphygma exigua* on leguminous crops ; *Myllocerus maculosus* and *M. laetiverens* on several field and orchard crops ; *Aulacophora foveicollis*, *Dacus ciliatus* and *D. cucurbitae* on cucurbits in general.

16. Immature Stages of Indian Insects.

The life-history of the following insect pests was studied in detail :—(1) *Euproctis lunata* (2) *Anomis flava* (3) *Hypera medicaginis* (4) *Acontia graellsi* (5) *Plutella maculipennis* and (6) *Amsacta moorei*.

17. The Imperial Pusa Collection.

During the period under report over 7,500 specimens belonging to about 50 species of Lepidoptera were registered and card catalogued. Nearly 200 species were added to the Collection and of these a large number are new to the collection.

IV. ADVISORY.

(*a*) *Identification of insects* .— Altogether 2694 species of insects were received for identification from the entomologists of provinces and states, and Agricultural Officers in India and most of them were identified.

(*b*) 275 enquiries on information about insect pests and advice on various problems were received from various correspondents in India, the United Kingdom and China and were attended to.

(*c*) *Bee-Keeping*.—Numerous enquiries about the science and practice of been keeping were received from all parts of India and detailed information was given.

(*d*) *Examination of research papers, bulletins etc. for publications*.—About 70 research papers and bulletins were examined in detail and reported upon regarding their suitability for publication in various journals.

(*e*) About 800 coloured plates of various crop pests were supplied to correspondents in different parts of India. Several consignments of grains meant for export were properly treated and certificates of their being free from insects were issued.

REPORT OF THE LOCUST WARNING ORGANISATION

(HEM SINGH PRUTHI)

I.—GENERAL.

I continued to act as Head of the Locust Warning Organization as Imperial Entomologist from 1941 to February 1944 and thereafter as Director, Locust Control in India, in addition to my duties as Director, Imperial Agricultural Research Institute, New Delhi.

In March 1939, the Government of India established a permanent Locust Warning Organization consisting of two gazetted officers, one posted at Delhi to assist the Imperial Entomologist and the other as Superintendent, Locust Substation, Karachi, five Locust Assistants and 12 Mukaddams.

With the outbreak of a fresh locust cycle, this staff was increased on a temporary basis and nine more Locust Assistants were recruited to cope with the changed locust situation. An additional Assistant Locust Entomologist was appointed at the headquarters at New Delhi to assist in the increased work. Necessary subordinate staff for field work was also provided.

In 1942, the Government of India in consultation with the representatives of various States and Provinces which were likely to be affected by locust invasion, sanctioned a Scheme to coordinate the anti-locust work in various States and Provinces and to render technical advice to the local administrations. Under this Scheme five Locust Technical Officers and seven Assistant Locust Technical Officers were appointed and posted in different regions. The main principle was that all administrations were to kill locusts in their areas, but the expenditure on control work incurred in scheduled desert areas was to be shared by all beneficiary Provinces and States liable to locust invasion irrespective of the fact whether breeding occurred in the latter or not. The organization proved very useful and in the following year a Deputy Locust Entomologist (Class I) was appointed to assist the Imperial Entomologist in the supervision of control work. By the end of 1943 one more gazetted officer (Second Superintendent was appointed at Karachi substation, which was functioning as the supply centre and disbursement office for the whole organization. To properly supervise locust intelligence work in Mekran an Assistant Locust Entomologist was appointed. Subsequently to enable the Superintendent at Karachi to take quick action in administrative matters and supervise more thoroughly locust intelligence work the post was raised to Class I status (Deputy Locust Entomologist).

With the increase of work additions were also made in the clerical staff both at Delhi and Karachi from time to time.

II.—PROGRESS OF LOCUST BREEDING AND CONTROL.

1941-42.—There was hardly any breeding in Baluchistan in spring. The waves of exotic swarms which invaded India from the west during June and July 1941 entered Rajputana and laid eggs over vast areas and by the end of November the locusts had produced two generations. The home-bred swarms which started originating about the middle of September invaded, in addition to whole of Rajputana and Sind, western parts of the United Provinces, northern parts of Central Provinces and southern and western districts of the Punjab reaching the N.-W. F. P. in the north. The swarms did some damage to *Kharif* crops at several places. In October, the swarms generally started flying in the western direction and flew over

Baluchistan during December. A very small number of swarms left India, some flew towards the eastern hilly tracts of Baluchistan. There was no over-wintering of the locusts in the Punjab, a few specimens were found in Rajputana and parts of Sind but Baluchistan continuously maintained some locust population. The winter-spring (1941-42) rainfall in Baluchistan was on the whole heavier than in the previous year but due to comparatively lesser locust concentrations, the spring and early summer breeding in Mekran and the interior of Baluchistan was comparatively light. It was mostly on the Mekran coast, some in Jhalawan and a little in Las Bela and Kachhi. Necessary control measures were undertaken in all parts of Baluchistan and no incipient swarming was reported from any locality.

1942-43.—Though breeding in Baluchistan during spring or early summer was light, in Iran, Oman (Arabia) and other winter rainfall areas heavy breeding took place. A large number of swarms developed in the latter areas. Exotic swarms started entering India early in June. The swarms were subsequently noted in several parts of Sind and almost all the States of Rajputana and some south-western districts of the Punjab and western districts of the United Provinces. In the south the swarms were observed up to Vasna (South of Baroda). Soon after the break of monsoons in the middle of June breeding started over extensive areas in eastern Rajputana, Northern parts of Central India, Gwalior State and south-western districts of United Provinces. Breeding was light in the western Rajputana and in Thar Parkar district of Sind. In other areas active breeding continued and whereas most of the hopper bands were destroyed, some escaped destruction and formed swarms early in August. These swarms invaded the western parts of Rajputana, Sind and Bhawalpur. About this time further incursions of locusts from west took place and these got intermixed with the homebred swarms. By this time western half of Rajputana, Sind and Bahawalpur had also received good rainfall and heavy breeding started in these tracts. During the second generation breeding good control work was carried out except in Jaisalmer and some adjoining areas which gave rise to a few swarms. Some of these home-bred swarms flew towards west but the majority of them took a north or north-easterly direction. About half a dozen of the swarms which flew towards west crossed the Indian Frontier into Iran and Arabia.

A small number of swarms over wintered in northern Punjab and western Sind and oviposition occurred in these localities in January and February respectively. Towards the end of January some swarms appeared in western Mekran (Baluchistan) and laid eggs. The hoppers were promptly controlled but in some parts of the Punjab a number of hopper bands escaped destruction and formed swarms which penetrated the North West Frontier Province and led to late spring breeding. In Mekran the control operations were completed thoroughly by the end of March but early in April several fresh swarms came from Persian side and spread over whole of Baluchistan and laid eggs. Late spring breeding occurred in western Mekran, Jhalawan, Kharan and Chagai district but the hoppers were effectively controlled.

1943-44.—Whereas some of the immigrant swarms referred to above, that came from Persia during April, remained in western Baluchistan and laid eggs, others flew eastward and reached Kachhi and Bahawalpur areas by the end of April. During May and June they penetrated into Sind, Rajputana, Western India, United Provinces and Bihar and Central Provinces. Since in Persia breeding continued upto the middle of July and large number of hoppers escaped destruction in that country,

India was invaded by a second wave in the end of May and subsequent incursions continued upto August. To some extent they were supplemented by swarms which developed in northern Punjab and N.-W. F. P.

Although numerous swarms were present in Sind and Rajputana deserts during May, egg-laying did not start till the commencement of rains after the middle of June. Earliest egg-laying took place in Jodhpur, Bikaner, Jaisalmer and Jaipur States. During the second week of July heavy rainfall was received and this was followed by egg laying on a large scale in the whole of Thar Parkar district of Sind, Northern and western parts of Jodhpur, almost whole of Jaisalmer and Bikaner, Sheikhawati desert of Jaipur and southern parts of Bahawalpur State. Some semi-desert districts of Jaipur State and Hissar district of the Punjab were also affected. From about the end of August to 18th September further egg laying took place in Northeastern Bikaner, Sheikhawati desert, Ferozepur, Hissar and Ludhiana districts of the Punjab and parts of Bahawalpur, Patiala, Nabha and Loharu States. Energetic control work based on trenching and baiting and burning was carried out almost every where and most of the hoppers were destroyed in the early stages. In spite of the heavy breeding only about half a dozen small swarms developed during September. Most of these flew towards south west and reached the sea coast, between Karachi and Cutch. One swarm penetrated as far as Hab river, near Karachi and this was the westernmost point where swarm of the summer generation was noticed. No swarm was observed in any part of India after the 12th November and presumably they got scattered or perished into the sea. No swarm was observed to have penetrated into Mekran or crossed the Indian frontiers and entered Persia.

In view of the foregoing it was hoped that the locust cycle had been brought to an end by the successful control measures adopted by the anti-locust organizations in India in the monsoon breeding grounds. Unfortunately, however, India was once again unexpectedly invaded by swarms from Arabia during March—April 1944. Egg laying took place over extensive areas in Mekran, Jhalawan, Kahran, Chagai, Lasbela and Chaman areas of Baluchistan. In Sind also breeding occurred in the western parts, viz. Dadu and Larkana districts. More exotic swarms about one dozen in number entered Sind and Rajputana in June 1944.

III.—LOCUST ACTIVITIES OUTSIDE INDIA.

1. Persian Delegation 1942.

At the invitation of the Iranian Government Dr. Taskhir Ahmad, Assistant Entomologist with a party of about half a dozen assistants, went to Persia in spring 1942 and carried out locust control operations successfully in parts of southwestern Persia.

2. International Locust Conference, Tehran, October 1942.

Dr. H. S. Pruthi, Imperial Entomologist (Head of the Locust Organization in India) visited Persia from 1st to 15th October 1942 to attend the International Locust Conference held at Tehran. He explained with the help of maps and statements the history of locust breeding during the past two years and the anti-locust organizations (Central & Provincial) and methods of locust control in India and

showed how both in 1941 and 1942 practically no swarms originated from Baluchistan in spite of sudden invasion of locust swarms in successive waves from the west during months of June and July. He further showed that the number of swarms which immigrated towards the west in autumn 1941 was very small and hoped that the same would occur in 1942.

3. INTERNATIONAL LOCUST CONFERENCE, TEHRAN, MARCH—JUNE, 1943.

Dr. K. D. Baweja, Superintendent, Locust Sub-station, Karachi, attended the International Locust Control Committee, Tehran, from 29th March to 18th June 1943. He gave further information about the (*i*) improvements affected by the Government of India in the Locust Warning Organization and Coordinated Scheme, (*ii*) inauguration of locust cycle in India in 1940 and breeding and swarm movements upto May 1943, and (*iii*) Control operations carried out from 1940 to 1943. The work of Dr. Baweja was highly appreciated both by the Committee and the British Embassy, Tehran.

4. INDIAN LOCUST DELEGATION TO ARABIA AND IRAN, DECEMBER 1942—JUNE 1943.

This delegation was lead by Mr. N. A. Janjua, Entomologist Baluchistan, and consisted of a dozen personnels. They worked in Oman, Trucial coast and Iran.

In Iran the area entrusted to delegation for control work along the coast extended from Gobra to Jask (Long ·56°6—57°48′E and Lat. 25°37′—27°43′N) over a distance of about 600 miles and inward from Kirman to Bum. This extensive area was divided into zones and staff deputed as available.

The work of the delegation was appreciated by Mr. O. B. Lean, Locust Officer in Persia.

5. INTERNATIONAL LOCUST CONFERENCE, CAIRO, JULY, 1943.

Dr. H. S. Pruthi, Imperial Entomologist (now Director Locust Control) attended the meeting and gave an account of locust breeding and its control in Baluchistan during winter spring 1942-43. He pointed out how towards the end of January some swarms appeared in western Mekran and laid eggs and the control operations were completed by end of March, but early in April several new swarms invaded India from the west and spread over whole of Baluchistan. Breeding occurred and was brought under control.

6. INTERNATIONAL LOCUST CONFERENCE, TEHRAN, JANUARY—MARCH 1944.

Dr. K. D. Baweja, Deputy Locust Entomologist, again attended the International Locust Control Committee from the 16th January to 15th March, 1944 and in continuation of his previous talks, gave detailed information on locust breeding and its control in Baluchistan and Sind-Rajputana during winter-spring 1942-43 and summer 1943 respectively. He also gave an illustrated discourse in the Anglo-Persian Institute, Tehran, on " Desert Locust, its periodicity and control in India " it the request of the British Council in Iran.

7. Anti-locust operations in Persian Mekran, February—June 1944.

At the request of the Locust Officer, Persia, the Government of India agreed to assume responsibility of locust control in Persian Mekran (Chahbar-Geh-Pishin Guatar area) and appointed staff comprising one Deputy Locust Entomologist, two Locust Control Officers and subordinates from February—June 1944 and also lent military transport and a squadron consisting of 60 camel sowars of the Bikaner Ganga Risala. Dr. K. D. Baweja was appointed Deputy Locust Entomologist The whole area was surveyed intensively from February-March. Swarm movement from the west started on the 27th March and breeding occurred in 4 sq. miles of Soman-Koh area along the Indo-Persian border. 1000 lbs. of poisoned bran were consumed 61 hopper bands trapped in 610 ft. length of trenches and 41 bushes burnt

8. Indian Locust Delegation of Oman, 16th January to 31st March 1944.

The delegation consisted of 4 Area Commanders and 6 Locust Jamadars. Eastern Arabia was expected to develop heavy breeding in spring 1944 but it failed due to low initial locust population and inadequate rainfall. Concentrated Breeding occurred only in 4 sq. miles and was soon controlled. Except for some infiltration of pink locust in third week of March from north-west, there was no other locust activity. Hence the delegation was entrusted with the work of patrolling BATNA and TRUCIAL coasts which they carried out efficiently.

APPENDIX I.

Training of Students and Research Works during 1941-44.

(a) Awarded Post graduate Diploma of the Institute.

Name.	*Subject of Thesis.*
	OCTOBER, 1941.
	Botany.
1. D. Srinivasachar, M.Sc. (Mysore) ..	Studies in the classification of *Oleiferious Brassicae* in India.
2. A. R. Braganza, B.Sc. (Bombay) ..	Seed and Embryo weight in its Relationship to Heterosis.
3. K. D. Sharma, M.Sc. (U.P.) . . .	Morphology and classification of the varieties of Solanum Andigenum Juz. et Buk. and their breeding value.
	Agricultural Chemistry.
4. K. D. Patel, B.Sc. (Baroda) . . .	Studies on Phosphate—Fixation in Indian cultivated soils.
5. M. K. Reddy, B.Sc. (Ag.) (Hyderabad) .	The study of the Plate and the direct methods for the estimation of total Bacterial numbers in the soil with special reference to the variation of sampling errors with grain size.
	Entomology
6. Shumsher Singh, B.Sc. (Burma) . .	A contribution to the study of Indian Terebrantia—classification of Terebrantia with a Systematic Account of the North Indian Genera and Species, their distribution and food plants.
7. Chandra Narain Modawal, M.Sc. (U.P.)	Part I "Studies on the Life History and Bionomics of Chilomenes sexmaculata Fabr. and its Predatory Efficiency in the Biological Control of Aphids". Part II "Review of previous work on the more important pests of cotton in India.
	Mycology
8. Syamaprasad Ray Chaudhuri, M.Sc. (Bengal).	(1) Studies on the canker disease of pigeon-pea (Cajanu. cajan (L) Millsp.) cause by Diplodia cajani Nov. Spec. (2) Studies on Erysiphe cichoracearum Dc and Drysiphe polygoni Dc.
	Sugarcane Breeding
9. Gur Prasad Seth, B.Sc. (Ag.) (U.P.)	Part I—Sugarcane Breeding as adopted at Coimbatore Part II—Different factors in sugarcane germination with special reference to nature of soil, its moisture content and variety. Part III—A possible method for selecting high yielding sugarcanes.
10. Jagdish Narain Sharma, M.Sc. (U.P.) .	Part I—Sugarcane Breeding at Coimbatore. Part II—Age determination of a sugarcane-culm. Part III—On the formulae of branching system of some of the sugarcane varieties in relation to poor harvest in some of them Part IV.—A preliminary study of root primordia in certain sugarcane seedlings and their parents.

OCTOBER 1942.

Botany.

Name.	*Subject of Thesis.*
1. U. Thein Aung B.Sc., (Ag.) (Burma)	Inheritance studies in Brassica. The Apetelous Gene and its linkage relationship.
2. M. V. Vachhani, M.Sc. (Sind)	Part I—A Preliminary study of self and cross Incompatibility factors in Toria. Part II—Inheritance studies in Gram. The Interaction of Factors governing the leaf character.
3. Hari Kishore, M.Sc. (U.P.)	Part I—Studies in the variability of vegetative characters in Triticum, as a basis for classification. Part II—Distinguishing the species of Triticum by the Phenol reaction.
4. H. P. Srivastava, B.Sc. (Ag.) (Bihar)	A study of differences in reciprocal crosses in relation to hybrid vigour.

Agricultural Chemistry.

5. N. M. Bose, M.Sc. (Bengal)	Part I—Studies on Nitrogen and Phosphorus intake of wheat as influenced by different fertilizers. Part II—A statistical study of phosphorus content of different varieties of wheat plant, etc. Part III—A study of relationship between crop response and available phosphorus as determined by different chemical methods.
6. M. C. Chhatrapati, B.Sc. (Bombay)	Part I—Effect of fertilizers on the nutrition, yield and composition of wheat. Part II—Study of the Nitrogen content of the wheat, plant as influenced by variety and fertilizers. Part III—Relation between available phosphorus of the soil and the phosphorus content of the wheat plant.
7. P. Thothadri, B.Sc. (Ag.), (Madras)	Part I—Relation of Fertilizer treatment to growth composition, yield and physical characteristics of wheat. Part II—Available phosphoric acid in soil and response of wheat.

Entomology.

8. T. D. Mukerjea, B.Sc. (Ag.) (U.P.).	Studies on the Biology and Morphology of some important cut worms with special reference to their colour variation.
9. K. K. Nirula, B.Sc., (Punjab)	Part I—Bionomics and control of Fruit fly (*Acanthiophilus helianthi Rose*) a pest of safflower in India. Part II—A Review of the work done on important Agromyzida in India.
10. Anantaram Panda, B.Sc. (Ag.) (Orissa).	Part I—Studies on the Biology and Physical Ecology of the common Indian Sugarcane stem-borer. Part II—Review of work on the parasites of Moth borers of sugarcane in India. Part III—*Diatraea Saccharulis*, F. (Lep. Paralidae). The moth borer of sugarcane in the new world. A Review since 1925.
11. A. Sashachalpati Rao, B.Sc. (Ag.) (Hyderabad).	A. Studies on Indian Aleurodoidea in 3 parts. B. Our knowledge of the insect and mite pests of the castor oil plant and their control.
12. R. K. De, M.Sc. (Bengal)	Part I—Studies on the biology of *Gnorimoschema* (*Phthorinaea*) Operculella (Zeller)—the Potato Tuber moth, with special reference to its ecology and control. Part II—A Review of the previous work on the Important Insect Pests of Rice in India.

Mycology.

13. N. N. Mohanty, B.Sc. (Orissa)	Part I—Study of Some Indian Aspergilli. Part II—The wilt disease of Pigeon-pea [*Cajanus cajan* (L) Millsp.] with special reference to some methods of dissemination.

14. Ali Sabir Fatmi, M.Sc. (Bhopal) . . Part I—Preliminary studies on the rotting of a green manure (*Crotalaria juncea* L.) with special reference to soil fungi concerned.
Part II—Studies on the germination of the spores of *Urocystis Tritici* Koem—The organism causing Flag smut of wheat in India.

15. Noel R. N. Dey, B.Sc. (Ag.) (Bihar) . Part I—A comparative study of the various apsects of some strains of *Sclerotinia selerotiorum* (lib) de Ry. attacking garden and crop plants.
Part II—Wilt and collar rot of ornamental chrysanthemums caused by species of Fusarium and by *Rhizoctonia solani* Kuhw.

Sugarcane Breeding.

16. Syed Majid Ali, M.Sc. (Bhopal) . . Part I—Effect of Saline and Alkaline Irrigation water on the growth of Sugarcane varieties.
Part II—Sugarcane Breeding at Coimbatore.
Part III—Study of the Epidermis of Leaf Blade and stem of some Co. canes.
Part IV—Study of some of the Gross Morphological characters of some Co. canes as a ready means for the identification of cane varieties in the field.

17. Sohan Bir Sihgh, B.Sc. (Ag.) (U.P.) . Part I—Sugarcane Breeding at Coimbatore and its importance in relation to the industry.

OCTOBER, 1943.

Name.	*Subject.*
	Botany.
1. Mr. A. V. Gokhale, B.Sc. (Bombay)	Part I—A method of estimating drought resistance of plant species. Part II—Studies in Cicer species—on the diploids and their colochicine induced tetraploids. Part III—Crossability in diploid & auto-tetraploid Toria (Brassica campestris L. Var. toria).
2. N. S. Reddy, B.Sc. (Ag.) (Madras)	Inheritance in Brassica. The Apetalous gene and its linkage relationship.
3. Abdul Alim, M.Sc. (Bengal)	Part I—Studies in the comparative development of diploid and auto-tetraploid chillies. Part II—Pistilloidy of stamens in Auto-tetraploid chillies.
4. Mohd. Sulyman B.Sc. (Ag.) (N.-W.F.P.)	Orobanche—Resistance of Nicotiana species.
5. M. B. Patkar, B.Sc. (Ag.) (Baroda)	Part I.—Studies in Sesamum (*a*) Flowering and Fruit formation (*b*) Induction of Plyploidy in Sesamum. Part II—The period of receptivity of the Stigma in toria (B. compestris var. toria and Rai (B. juncea).)
6. Mr. R. K. Bansal, M.Sc. (U.P.)	Part I—Studies in the seed-coat anatomy of Brassica species. Part II—Cytogenetical studies in the reciprocal crosses between auto-tetraploid toria (2nd = 40) and *B. juncea* (2nd = 36).
	Agricultural Chemistry.
7. S. K. Vardhan, M.Sc. (U.P.)	A preliminary study of the percentage, ratio and total output of Calcium and Phosphorous in Milk of the low milking Sahiwal breed of cows.
8. M. L. Mathur, M.Sc. (Ajmer)	Studies on Calcium and Phosphorous in Milk and Feeds of High Milking Sahiwal Cows.
	Mycology
9. M. K. Hingorani, B.Sc. (Ag.) (Sind)	A. Cultural and morphological study of some of the typical isolates of Collectotrichum falcatum to establish, if possible, some correlation between virulence and one or more of these characters. B. Variation in Collectotrichum falcatum.
10. M. Azmatullah, B.Sc. (Punjab)	This student died at the far end of the course and the Diploma was awarded posthumously in view of his very good work.
	Entomology.
11. Muzaffer Ahmed, M.Sc. (U.P.)	Part I—The biology and morphology of *Rhogas* testaceus (Spinola), a Braconid parasite of the spotted boll-worms of cotton. Part II—Our present knowledge of some important insect pests of mango in India (A review).
	Sugarcane Breeding.
12. Karkaran Singh Rana, B.Sc. (Ag.) (U.P.).	A new addition to the existing forms of *Saccharum spontaneum* L. at the Sugarcane Breeding Station Coimbatore etc., etc.
13. Rais Dullah Khan Emazie, B.Sc. (Ag.) (Rampur).	Raising sugarcane seedlings at Coimbatore Arrowing (Flowering) as related to order or tillering in a sugarcane clump. etc., etc.
14. Sohan Bir Singh—*contd.*	Part II—Identification of sugarcane varieties on the basis of the Anatomy of Epidermal peelings of leaf-blade and leaf-sheath. Part III—Sugarcane Agronomy in India with particular reference to the United Provinces. Part IV—Sugar Industry in India.

(b) *Awarded Post-graduate Certificate in Agriculture*

1941—42.

1. K. R. Choudhry (Punjab).
2. K. L. Gurnani (Sind).
3. Mohammad Amir (Punjab).

1942-43

1. Ajit Singh Dhesi (Punjab).
2. A. Rahim Khan (U.P.).

1943-44

1. Umar Din (Punjab).
2. Fida Ali Khan (Rampur State).
3. Mohd. Charagh (Punjab).
4. P. J. Jinendradasa (Ceylon).

(C) *Students Admitted for Short courses of Training.*

Name.		*Section.*	*Period of stay*
1. Pritam Singh (Patiala State)	1942	Agriculture	6 months.
2. H. L. Sarkar (Bengal)		Entomology	2 ,,
3. Narinder Chand		Chemistry	2 ,,
4. G. L. Maheshwari (U.P.)		Chemistry	3 ,,
5. K. L. Sarkar (Bhopal State)		Chemistry	6 ,,
6. Dr. B. Singh (U.P.)		Mycology	1½ ,,
7. Bhanwar Singh (U.P.)		Agriculture	2 ,,
8. Ch. Misri Lal (U.P.)		Dairy	2 ,,
9. Shri Kirti Vardhan (U.P.)		Chemistry	3 ,,
10. Shambhunath Kaul (Kashmir)		Agriculture	6 ,,
11. M. A. Idrani		Chemistry	3 ,,
12. S. V. Srinivasan (Madras)		Chemistry	2 years.
13. Dip Chand (Kangri)		Dairy	2 months.
14. G. H. Desai (Baroda)		Mycology	3 ,,
	1942-43		
1. M. A. Saleem (Aligarh)		Mycology	1½ ,, months.
2. P. Roy (Bengal)		Chemistry	5 ,,
3. B. Joga Rao (Madras)		Chemistry	6 ,,
4. B. G. Nikam (Gwalior)		Mycology	6 ,,
5. K.K. Nanda		Botany	
1. K. S. Vijayaraghavan (Baroda)	1943-44	Botany	1 month.
2. B. Parija Singh (Patiala State)		Agriculture	6 ,,
3. V. D. Kamath (Madras)		Botany	4 ,,
4. Dr. L. N. Seth (Burma)		Botany	15 ,,

(d) *Honorary Research Workers.*

1941-42

Name.	*Subject.*
1. P. L. Chaturvedi (U.P.)	Morphological characters of certain moth borers of sugarcane.
2. Narendra Singh Arsen (U.P.)	Mouth parts of Lepidoptera.
3. J. L. Merh	Identification and Taxonomic work on certain fungi.
4. J. Thuljaram Rao (Madras)	Anatomy of Saccharum and its Hybrids (awarded the M.Sc. degree of the Madras University).
5. Birendra Singh (Punjab)	Interspecific Cross between wild and cultivated safflower.
1. S. P. Roy. Choudhuri (Dacca) 1942-43	Identification of certain fungi collected at Dacca.
2. Mr. C. L. Subramaniam (Madras)	The Cytological behaviour of certain parthenogenetic sugarcane.
3. Sham Singh Kapur (Punjab)	The Neuro-muscular system of the AK-grass hopper.
4. K. D. Sharma (U.P.)	Research on Potatoes with special reference to varieties.
5. Hari Kishore (U.P.)	Studies on certain wheat varieties.
1. Atiqur Rahman Ansari (Punjab) 1943-44.	Mallophaga from the birds of Punjab.
2. S. Kedarnath (Madras)	Genetics and Anatomy of some Sugarcane Hybrids in relation to disease resistance.

APPENDIX II.

List of Papers Published During 1941 to 1944.

Ahmed T. and Ghulam Ullah. — The fecundity and longevity of *Earias fabia* and *Microbracon lefroyi* under different conditions of temperature and humidity, Indian J. Ent. Vol. III. pt. 2, 1941.

Burns, W., and Pal, B. P. — The relationship of agricultural science with taxonomy and cytology Roy. Bot. Gard., Calcutta. 150 (Ann. Vol.): 227-232.

Chinoy, J. J. — A review of 'Frost killing and Hardiness of Plants' by J. Levitt. India. J. Gneet. Pl. Breed. 3: 135-136.

Chinoy, J. J. — Pre-sowing treatment and phasic development Curr. Sci. 11 : 400-402.

Chona, B. L. — Sugarcane Smut and its control, Indian Farming, IV, 8, 1943.

Chona, B. L. — Red-rot of sugarcane and its control. Indian Farming IV : 27-32, 1943.

Chona, B. L. and Padwick, G. W. — More light on the red-rot epidemic. Indian Farming 3, 70-73, 1942.

Datta, S. C., and Biswas, S. C. — Vinegar from sugarcane and fruit juices. Indian Farming Vol. III, No. 10, October, 1942.

Deshpande, R. B. — A case of chlorophyll deficiency in safflower (*Carthamus tinctorius L.*) Curr. Sci., 12 : 273-274.

Deshpande, R. B. — The cultivation of chillies. Indian Farm. 4 : 188-191.

Deshpande, R. B. — Inheritance of leaf lobe in *Hibiscus cannabinus* L. Indian J. Genet. Pl. Breed. 2 : 181-182.

Deoras, P. J. — The internal anatomy and description of *Hemimerus deceptus*, with remarks on the systematic position of the family *Hemimeridae*. *Indian* J. Ent., Vol. III, Pt. 2, 1941.

Deoras, P. J. & Jandu, A. S. — The house-fly and its control, *Indian Farming*, Vol. IV., No. 11, 1943.

Dunnicliff, H. B. & Padwick, G. W. — Biological Examination of Some Indian Hide curing Salts. Industrial and News Ed. J. Indian Chem. Soc. VI : 4-22, 1943.

Dutt, N. L. — Indian canes Abwad-Indian Farming Vol. II, P. 605, 1941.

Dutt, N. L. — The present position of thick Coimbatore Sugarcanes *Indian Farming*, 1942, Vol. 3, No. 9 pp. 473-477.

Dutt, N. L. — Control of flowering in Sugarcane, *Indian Farming*. 1943, Vol. 4, No. 1 pp. 11-13.

Dutt, N. L. and Krishnaswami, M. — Protogyny in Uganda Spontaneum, *Current Science*, 1943, Vol. 12, No. 1 pp. 24-25.

Dutt, N. L. — Varietal Composition of the Sugarcane Crop in India in 1941-42 Ind. Jour. Agric. Sci., 1943, Vol. 13, pp. 471-478.

Ekbote, R. B. — Genetics of two mutations in *Cicer*. Indian J.Genet. Pl. Breed. 2 : 50-65.

Ghulam Ullah — Aphididae and some other Rhynchota from Afghanistan. *Indian* J. Ent. Vol. III, pt. 2, 1941.

Isaac, P. V. — Prevention on house-fly breeding-*Indian Farming* Vol. V, No. 2, 1944.

Krishna Iyer, P. V. and Ahmed, S. Azizuddin. — Efficiency of some sampling method for wheat crop, *Curr. Sci.* September, 1943, 12, 258-259.

Krishna Iyer, P. V. — A note on the Generalized Variance of Mulrivariate Populations—*Current Sceince*, May, 1944, *13*, 125.

Krishna Iyer, P. V. — An Extension of the Newtonian Relation, *Curr. Sci.*, *12*, 1943, p. 113.

Krishna, Iyer, P. V. — Analysis of Experiments by splitting the Treatment Sum of Squares. *Sci. & Cult.* Vol. 7, 1942, p. 570.

Do. — Studies with Wheat Uniformity Trial Data. I-III. *Indian Jour. Agric. Sci. 12*, 1942, pp. 240-280.

Mani, M. S. — Studies on Indian Itonididae. *Indian J. Ent.* Vol. IV, Pt. 1, 1942.

Mani, M. S. — Studies on Indian Parasitic Hymenoptera-II, *Indian J. Ent.*, Vol. IV, P. 2, 1943.

Menon, R. G. — Studies on Indian Copeognatha II, Nanopsocetae and Psocatropitae *Indian J. Ent.* Vol. IV, Pt. 1, 1942.

Mohan Singh — House-hold insect pests and their control *Indian Farming*, Vol. IV, No. 12, 1943.

Moorthy, R. B. — Report on the malting tests of the U.P. barley Imp. council of Agri. Research Publication 1941.

Mundkur, B. B. — Studies indian. Cereal Smuts, V. Mode of transmission of the Karnal Bunt of wheat. Indian J. Agric. Sci. XIII : 54-58, 1943.

Mundkur, B. B. — Taxonomic studies of Indian Smuts. 150th Anniversary Volume R bot. Gdn. Calcutta, pp. 221-225, 1942.

Mundkur, B. B. . Notes on *Sacc hirun and Erianthus* Smuts. Kew Bulletin, 3, 209-217, 1941.

Mundkur, B. B. . Studies n Indian Cereal Smuts, II. Varietal Resistance of Indian and other wheats to loose smuts. Indian J. Agric. Sci. Vol. XI, 675-686, 1941.

Mundkur, B. B. . Studies in Indian Cereal Smuts, III. Varietal Resistance of Indian and other wheats to flag smut. Indian J. Agric. Sci. Vol. XI, 687-694, 1941.

Mundkur, B. B. (with R. D. Bose as Senior author.) Studies in Indian Cereal Smuts, IV. Varietal Resistance o f Indian and other oats to Smuts. Indian J. Agric. Sci. Vol. XI, 695-702, 1941.

Mundkur, B. B. and Kheswalla, K. F. Indian and Burmese species of the genera *Pestalotia* and *Monochaetia* Mycologia, 34, 468-481, 1942.

Mundkur, B. B. and Pal, B. P. Studied in Indian cereal smuts. II. Varietal resistance of Indian and other wheats to loose smut Indian J. Agric. Sci. Vol. XI, 663-86.

Mundkur, B. B. and Kheswalla, K. F. A new genus of Uredinales, Mycologia, pp. 201-206, 1943.

Mundkur, B. B. and Kheswalla, K. F. A canker of apples in Mysore. Indian J. Agric. Sci. xiii, pp. 397-398, 1943.

undkur, B. B. and Thirumalachar, M. N. *Catenulopsora*, a new genus of rusts. *Ann. Bot. Lond.* n.s. vii, pp. 213-220 1943.

Mundkur, B. B. . Indian species of *Phakopsora* and *Bubakia*. *Mycologia*, pp. 538-554, 1943.

Mundkur, B. B. . Karnal Bunt, an air-borne disease. Current Science, xii, pp. 230-231, 1943.

Mundkur, B. B. . Sir Edwin Butler, F. R. S. Obituary Notice . Current Science xii, 249-250, 1943.

Mundkur, B. B. . Studies in India n cereal smuts. VI. The smuts of Sawan [*Echinochlo frumentacea*, (Roxb.) Link.) Indian J. agric. Sci. 13 : 631-633, 1943.

Mundkur, B. B. . *Tilletia tumefaciens*, a remarkable gall-forming smut from India. Phytopathology, xxxiv, pp. 2143-146, 1944.

Mundkur, B. B. . Fungi of the North West Himalaya : Ustilaginales. Mycologia, xxxvi pp. 286-292, 1944.

Mundkur, B. B. . Some rare and new smuts from India, Indian J. agric. Sci. 14 : 49-52, 1944.

Narayanan, E. S. . Bionomic and life-history of *Coniopteryx pusana* (Neuroptera). *Indian J. Ent.*, Vol. IV, Part 1, 1942.

Padwick, G. Watts . China's Rich Earth. Indian Farming, IV, 448-450, 1943.

Padwick, G. Watts and Merh, J. L. Notes on Indian Fungi. 1. Mycological Papers, Imperial Mycological Institute, Kew, No. 7, July, 1943.

Padwick, G. Watts, and Azmatullah, Md. *Claviceps purpurea* (Fr.) Tul. and a new species from Simla. Current Sci., XII, 257, 1943.

Padwick, G. Watts and Mundkur, B.B. Kulkarni's note of Baluchistan Sulphur. Current Science, xiii, 48-49 1944.

Padwick G. Watts and Bhagwagar, P. R. Wilt of gram i n relation to date of sowing . Indian J. Agric. Sci. XIII, 289-290, 1943.

Padwick G. Watts . Recent advances in control of fungous Diseases of Plants. Indian Fmg. III, 478-481, 1942.

Padwick, G. W. . Some problems of Control of Soil-borne Fungal Diseases of Plants. 150th Anniversary Volume. R. Bot. Gdn. Calcutta, 1942 : 213-220.

Padwick, G. W. . Mushroom cultivation in India. Indian Farming Vol. 2, 363-366, 1947.

Padwick, G. W. . The Genus Fusarium. VI. A recent attempt at mass revision. Indian J. Agric. Sci. Vol. XI, 663-674, 1941.

Padwick, G. W. . The use of field observation in classifying Fungi Imparfecti. Proceeding of the National Academy of Sciences, India Vol. XI, 74-84, 1941 .

Padwick, G. W. and Pushkarnath (senior author.) Ergot in India. Current Science, 10 : 488-489, 1941.

Pal, B. P. . Degeneration of improved crops in India. Indian Farm., 3 : 261-64.

Pal, B. P. and members of a special Sub-Committee The description of chrop-plant characters and their ranges of variation III. The variability of Indian Wheats. Indian J. Agric. Sci., Vol. XI: 477-92.

Pal, B. P. and Mundkur, B.B.	Studies in Indian cereal smuts. III. Varietal resistance of Indian and other wheats to flag smut. Indian J. Agric. Sci., Vol. XI : 687-94.
Pal, B. P. and Murty, G. S.	Studies in the vernalization of Indian crop plants. 1. Preliminary experiments on gram, wheat, chilli and soybean. Indian J. Genet. and Plant Breed., 1 : 61-86.
Pal, B. P. and Nath, Pushkar.	Genetic nature of self and cross incompatibility in potatoes. Nature, 149 ; 246-47.
Pal, B. P. , Ramanujam, S and Joshi, A. B.	Colchicine-induced polyploidy in crop plants. II. chilli (*capsicum annum* Indian J. Genet. and Plant Breed., 1 : 28-40.
Pal, B. P.	Virus diseases of potatoes in India. Curr. Sci. 12 : 279.
Pal, B. P. and Narayana Rao, T.	Pure Tobacco Seed. Indian Farm. 4 : 419.
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